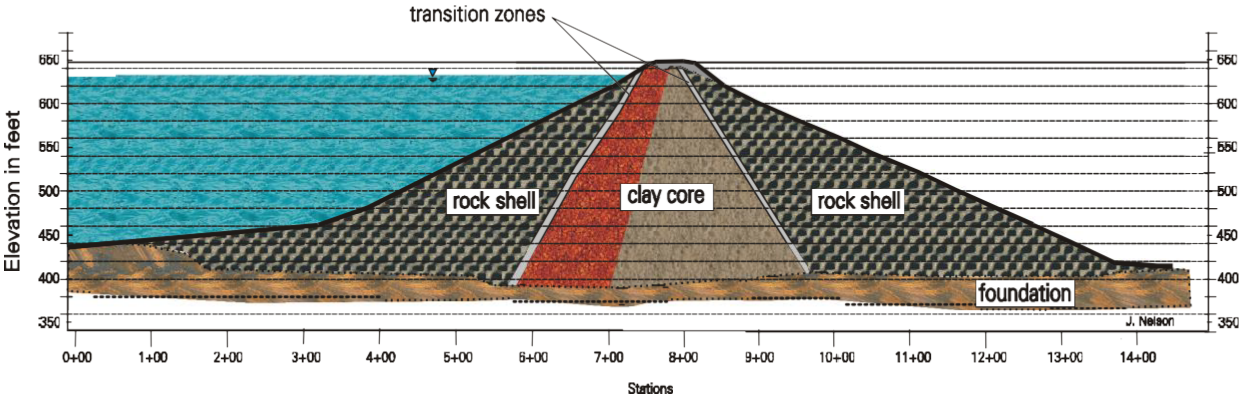
December 2009

FOURTH INTERIM
SURVEILLANCE REPORT
December 2008 Through December 2009
LEROY ANDERSON DAM NO. 72-9,
Santa Clara County



Santa Clara Valley
Water District℠

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January 13, 2010

Mr. David A. Gutierrez, Chief
Division of Safety of Dams
Department of Water Resources
1416 Ninth Street
P.O. Box 942836
Sacramento, CA 94236-0001

Subject: Leroy Anderson Dam, No. 72-9, Santa Clara County
December 2008 through December 2009
Fourth Interim Surveillance Report

Dear Mr. Gutierrez:

Enclosed with this letter are two copies of our Fourth Interim Surveillance report for Leroy Anderson Dam No. 72-9.

The surveillance data from Anderson Dam and the Santa Clara Valley Water District's (District) field observations confirm acceptable performance of the dam for the period of this report, with the dam showing normal responses to the environment, and external events. The District will continue with the current monitoring program and safety inspections, and will keep DSOD informed of any significant changes pertaining to the surveillance or performance of Leroy Anderson Dam.

Although there were no major incidents or changes at the dam during 2009, an operating restriction for Anderson Reservoir was implemented under the direction of the DSOD and monitored by District Operations and Planning Unit beginning in January 2009. This operating restriction was implemented to provide an added margin of safety in response to preliminary seismic stability results for Anderson Dam. Except for the new operating restriction at Anderson Reservoir of approximately 40 feet total freeboard, there are no substantive changes in dam or reservoir response compared to previous years.

As discussed in more detail in the attached surveillance report, the District will address several Automated Data Acquisition System (ADAS) related problems that have been affecting piezometer and in-place inclinometer sensor data gathering at Anderson Dam before the next surveillance report. The District will keep DSOD apprised of the status of the work to address ADAS issues.

Please contact me at (408) 265-2607, extension 2736, if you have any questions.

Sine

James M. Fiedler
Chief Operating Officer
Water Utilities Enterprise

Attachments
cc/att: D. Hook, M. Mooers, B. Baker, S. Wu, J. Nelson, library (4), F. Makdisi (AMEC Geomatrix)
cc: F. Maitski, R. Jacobs
jn:fd
1229a-l.docx

The mission of the Santa Clara Valley Water District is a healthy, safe and enhanced quality of living in Santa Clara County through watershed stewardship and comprehensive management of water resources in a practical, cost-effective and environmentally sensitive manner.

FOURTH INTERIM SURVEILLANCE REPORT

December 2008 Through December 2009

LEROY ANDERSON DAM NO. 72-9, Santa Clara County

Date of photo 10/10/06
Photo shows temporary drill rig access roads and 2 drill rigs on dam crest for DIP

Prepared for:

State of California
Department of Water Resources
Division of Safety of Dams
P.O. Box 942836
Sacramento, CA 95236

Prepared by:
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5750 Almaden Expressway
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December 2009

FOURTH INTERIM
SURVEILLANCE REPORT
December 2008 Through December 2009
LEROY ANDERSON DAM NO. 72-9,
Santa Clara County

The analysis and interpretation of the instrumentation and other relevant data presented in this report has involved the application of certain graphical and statistical interpretive techniques common to the geosciences and earth dam engineering professions. The conclusions presented in this report were developed upon evaluating the performance of all instruments and other pertinent data during the specified period, and represent the professional judgment of its author. This report was submitted on December 31, 2009.

Report prepared by:

JAMES LEWIS
NELSON
No. 1463
CERTIFIED
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James L. Nelson, C.E.G.
Senior Engine ist
Dam Safety P 1

Quality Control/Quality Assurance

This report has been reviewed and approved for publication by the undersigned professional engineers. attest and confirm that the report was prepared by the individual who signed the report under my immediate direction and supervision and that the conclusions and recommendations presented herein are reasonable and supported by District management.

Reviewed and approved by:

2

David E. Hook, P.E.
Engineering Unit Manager
Dam Safety Program Unit

Reviewed by:

Steven M. Wu

Steven M. Wu, P.E., G.E.
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1.0 INTRODUCTION

1.1 Scope and Purpose

This Fourth Interim Report contains surveillance data collected from Anderson Dam, No. 72-9, from December 2008 through December 2009. The focus of this Interim Report is to review the data for overall accuracy and to make assessments of general data trends. If any significant geotechnical or operational events have occurred (i.e., earthquakes, sustained elevated reservoir levels, significant operational or maintenance changes, or dam instrumentation/monitoring changes), these are addressed to the appropriate level in this report. The reader is referred to previous reports for earlier data.

1.2 Recent Instrumentation and Safety Studies

1.2.1 Supplemental Work Associated with FERC Part 12 Safety Inspection and Review

Since the last annual surveillance report (Nelson and Volpe, 2009), additional supplemental work associated with the last 5-yr FERC Part 12 safety inspection and review (GEI, 2007) was completed for the District by GEI Consultants. This supplemental work included 5 memorandums that provided 1) assessment of an unlined discharge channel downstream of the concrete-lined spillway during major reservoir spill events (GEI, 2009a), 2) partial evaluation of the seismic performance of the intake/outlet system (GEI, 2009b), 3) assessment of a downstream foundation drain (GEI, 2009c), 4) development of action levels for all geotechnical instrumentation installed in the dam and appurtenant structures (GEI, 2009d), and 5) the presence and general performance of both upstream and downstream transition zones separating the impervious core from the upstream and downstream rockfill zone (GEI, 2009e). Copies of these reports have been forwarded to Division of Safety of Dams (DSOD).

The District performed a visual inspection of Anderson Dam outlet pipe including the inclined inlet structure on November 9, through 12, 2009. Results of the inspection are summarized in a report by D. Hook (2009). It appears that the pipe and inclined inlet structure were last inspected in 1988 when the inclined outlet was constructed. Dates of the inspection and personnel present are summarized in Section *7.0 Visual Inspections And Maintenance Issues*. On November 9 and 10, 2009, the sloping inlet structure was observed by licensed commercial divers with Underwater Resources, Inc. and the outlet was observed by various engineering and maintenance personnel on November 12, 2009. The results of the inspection indicated that both the sloping intake and outlet appears to be in generally good shape with no obvious deformation as a result of distress (Hook, 2009).

1.2.2 Seismic Safety Evaluation – Preliminary & SSE1A

In December 2008 the District submitted to the DSOD a preliminary report based on limited geotechnical data by AMEC Geomatrix Consultants (AMEC) that indicated a potentially inadequate factor of seismic safety of Anderson Dam (AMEC, 2008). Actions taken by the District due to the findings of the report included 1) implementing an operating restriction (discussed later in more detail), 2) accelerating the schedule for completing a full seismic stability evaluation (SSE1A), and 3) providing outreach to downstream stakeholders.

Currently, AMEC is performing a full seismic stability evaluation (SSE1A) of Anderson Dam that will supersede the preliminary report and provide an in-depth assessment of seismic stability. The SSE1A report is scheduled to be completed by December 31, 2010. The SSE1A work also includes a detailed seismotectonic study by Fugro William Lettis Associates (FWLA) for all District Dams included as an attachment to a report by AMEC (2009a). The originally planned exploration and laboratory testing phase of work of the SSE1A for the embankment is complete, which will be followed by analyses and a technical report by late 2010. Preliminary results including drill hole logs and well construction sheets of the two new open well piezometers (OW-2 and OW-3) are summarized in the AMEC draft report (2009d). Pertinent findings of SSE1A with respect to dam safety surveillance are included in this surveillance report (see Section *2.2.2 Open Well Piezmeters*). The District will continue to keep DSOD informed and involved regarding the SSE1A study results for Anderson Dam.

2.0 BACKGROUND INFORMATION AND METHODOLOGY

During the time period covered by this report, the District monitored 2 pneumatic piezometers in the dam, 2 spillway underdrain seepage weirs, 15 dam crest survey monuments, 2 spillway training wall survey monuments, 3 open well piezometers, 31 vibrating wire piezometers and 6 in-place inclinometer sensors. As mentioned above, the District began monitoring two open well pieozmeters OW-2 and OW-3 through the downstream rock shell into the underlying foundation. The locations of crest monuments, spillway training wall monuments, original and new piezometers, accelerometers, and the spillway underdrain weirs at Anderson Dam are shown in plan in Figure 1, and in section in Figures 2 through 4. Specifically, Figure 2 presents a transverse cross section A-A' through a minor section of the left abutment of the dam. Figure 3 presents cross section B-B' near the maximum section of the dam. Figure 4 presents a longitudinal section C-C' along the crest. The sections show new vibrating wire piezometers, original pneumatic piezometers, open well piezometer OW-1, and new open well piezometers OW-2 and OW-3.

All new data covered in this report is presented in tabular form, and plotted to facilitate review. For the period of this report, data were collected annually for survey monument and monthly for original pneumatic piezometers and underdrain weirs. Data were collected from the new vibrating wire piezometers at various intervals as summarized in Section *2.1 General Surveillance*. Crest monuments were surveyed at the times indicated (typically near the end of every year).

All elevation data presented in this report have been adjusted for the current datum used by the District which is the North American Vertical Datum (NAVD) 1988, which is 2.80 feet higher than the old datum National Geodetic Vertical Datum (NGVD) at this location.

2.1 General Surveillance

Table 1 presents a list of locations for each vibrating wire piezometer (vwp), Table 2 presents a list of pertinent data of each in-place inclinometer sensor (IPIs), Table 3 summarizes piezometric surface elevations (PSE in ft) of original pneumatic piezometers and newer open well piezometers, and Table 4 summarizes spillway underdrain flow. Tables 5 and 6 summarize geodetic data from the dam crest and spillway training walls. All surveillance data are also shown graphically on Figures 5 through 19, and discussed later in the report.

Data from vibrating wire piezometers and in-place inclinometers are collected by an Automated Data Acquisition System (ADAS), which was implemented in early December 2008. Prior to installation of ADAS, manual data was collected from new vibrating wire piezometers at a frequency of ~1 to 4 times per month to generally correspond to rates of changes in reservoir elevation. Relatively rapid changes in reservoir level resulted in more frequent readings; conversely, less rapid changes resulted in less frequent readings. ADAS automatically collects piezometer and in-place inclinometer data at frequent intervals of

4 times per day from early December 2008 when ADAS was implemented. On June 10, 2009, the sampling frequency decreased to one data sample per day.

Beginning with this surveillance report, we are including data plots of the multiple automated bi-axial inclinometer sensors (in place inclinometers or IPIs) in a single inclinometer boring IPI9-3 located along the crest near the maximum section of the dam. For the DIP, this inclinometer boring was designated as inclinometer 72-9-ASI-1 (also designated as IPI9-3). As explained below in Section *2.5.2 In-place Inclinometer Sensors (IPIs)*, we have been collecting manual readings of the IPIs since September 16, 2008, because ADAS is not yet collecting viable IPIs data.

The purpose of the inclinometer boring is to monitor gross deformations of the embankment as a result of events such as significant earthquakes or rapid draw-down of Anderson reservoir. Two types of monitoring include frequent ADAS measurements of potential deformation of the boring with six in-place inclinometer sensors (IPIs) and periodic manual measurements using an inclinometer probe (described in more detail in Section *2.5.1 Manual Inclinometer Probe*). Although we do not expect the embankment to experience adverse deformations during normal fluctuations in reservoir levels, we are including this new instrument data in this report. To supplement the bi-axial sensor data, we also plan to perform conventional manual probe inclinometer surveys soon after significant seismic events, or more frequently as needed.

This report includes approximately 3 years of complete data from the new 31 DIP vibrating wire piezometers starting with their installation in late-December 2006 and continuing to early December 2009. In contrast, this report includes only a few months (June 2009 and October through December 2009) of water level data from OW-2 and OW-3.

During the period of this report there have been minimal changes in reservoir elevations (total excursion of ~19 feet) and relatively low reservoir elevations (between 26 and 44 feet below spillway lip). The maximum reservoir elevation achieved in 2009 of el. 602 ft was lower than the maximum reservoir elevation of 613 ft in 2008. In this report, new vibrating wire piezometer plots are grouped and presented as standard piezometer and reservoir plots versus time. Instrument locations are shown in Figure 1 in plan view and in Figures 2 through 4 in longitudinal and transverse section views.

The cross plots (Appendix A) are more likely to show subtle piezometric responses relative to minor changes in reservoir elevations (if applicable) because there is a more direct correlation between piezometric response and reservoir fluctuations than plots showing piezometric data versus time. Figures A-1 through A-31 includes individual cross plots for the 31 vibrating wire piezometers. In addition to showing possible trends and responses, these plots graphically show piezometer tip elevation, ground surface elevation above the piezometer tip, and spillway lip elevations.

Reported rainfall is measured at District Rain Gauge No. 41-2073, which is located a few hundred feet southeast of the left abutment of Leroy Anderson Dam.

2.2 Piezometers

2.2.1 Pneumatic Piezometers

Two original pneumatic piezometers (PPA-1 and PPA-2), installed in 1975, show slight fluctuations and response to changes in reservoir levels but are still operational after 34 years of service. A gap in the data occurs from December 2001 through March 2002 due to problems with the pneumatic data collection instrument. Recently the pneumatic readout box failed and a new one has been ordered and not received as of December 2009. Consequently, there is a data gap in the pneumatic piezometers starting in July 2009 to the present.

2.2.2 Open Well Piezmeters

Starting in September 2003, the District began collecting water level data from open well piezometer OW-1 soon after the well was installed in August 2003. New open well piezometers OW-2 and OW-3 were installed on April 30, 2009 and May 1, 2009, respectively. The locations of the open well piezometers are shown in Figures 1 and 3. AMEC collected a field water level reading on June 9, 2009 for SSE1A and the District began monitoring water levels in OW-2 and OW-3 in October 2009 (see Table 3).

AMEC installed two open well standpipe piezometers (OW-2 and OW-3) in 2009 through the downstream shell into foundation materials in two new borings to provide phreatic surface information needed to assess the Seismic Stability Evaluation (SSE1A) of Anderson Dam (AMEC, 2009d). AMEC constructed OW-2 in boring DH9-37SPTb on April 30, 2009 and OW-3 in DH9-49 on May 1, 2009. Copies of boring logs and well construction diagrams of OW-2 and OW-3 are included in their draft report (AMEC, 2009d). According to AMEC the open wells were developed with a hand bailer on May 21, 2009. The first stable depths to water levels were measurements by AMEC on June 9, 2009 with an electronic sounder. The initial depth to water was measured at 100.4 ft (elev. 407.2 ft) in DH 9-37SPTb and 138.9 ft (elev. 411.6 ft) in DH 9-49.

Well OW-2 was installed in DH9-37SPTb located in the downstream half of the downstream shell. This well targets the phreatic surface of a lower fine-grained unit of rockfill embankment encountered during the SSE1A and identified by AMEC as the “Lower Finer Fill” (LFF) at depths between 92 feet and 102 feet (~elevation 406 feet and 415 feet). The LFF appears to be predominantly beneath the downstream shell of Anderson Dam and is considered to be a potentially problematic soil with respect to seismic safety (AMEC, 2009). Well OW-3 was installed in DH9-49 located in the right-central portion of the downstream shell and targets the phreatic surface of various foundation soils including construction haul road fill and alluvium at depths between 133 feet and 143 feet (~elevation 408 feet and 418 feet).

2.2.3 Vibrating Wire Piezometers

Table 1 summarizes pertinent data of the new vibrating wire piezometers including location in the dam, tip elevation and surface elevation. The District manually collected data from 31 vibrating wire (VW) piezometers since their installation in late December 2006 to implementation of ADAS in early December 2008. From December 2008 to the present the data has been automatically collected by ADAS. The locations of the VW piezometers are shown in plan view in Figure 1 and in section views in Figures 2, 3, and 4.

As summarized in Table 1, locations of the piezometers include 16 VW piezometers in the downstream core (Zone 3) of the embankment, 1 VW piezometer in the upstream core (Zone 2) (with core piezometers shown as red symbols in Figures 2, 3, and 4), 3 VW piezometers in the downstream transition zone (yellow symbols), 2 VW piezometers in the upstream transition zone, 2 VW piezometers in alluvium/colluvium (green symbols), and 7 VW piezometers in foundation Franciscan Complex bedrock (blue symbols).

2.3 Spillway Underdrain System

The current spillway underdrain seepage monitoring program for Anderson Dam Spillway began in May 1993. At that time, the District only measured the "center" drainage system which collects seepage in the central portion of the spillway. The "left" drainage system discharged through boulders that were providing slope protection D/S of the spillway bucket and could not be measured.

The seepage system was modified with the construction of the two "V" notch seepage weirs in 1999 (with readings beginning April 2000) to allow measuring all the seepage instead of only a portion of the flow as occurred with the original center drainage system mentioned above. Weir #1 continues to measure the seepage from the "center" drainage system but is not affected by the restriction and backpressure created by the use of a meter as was the old system that it replaced. Weir #2 measures the seepage collected along the left (southern) side of the spillway.

The weirs where not read for three months in July, August, and September 2009 due to an internal resource issue.

2.4 Surface Monuments

During the period of this report crest monuments (No. 16 through No. 30) and training wall monuments (No. 14 and No. 15) were monitored at the locations shown in Figure 1 (plan view) and in Figure 4 (longitudinal section view).

Modifications to Anderson Dam in 1986-87 included raising the dam crest 4 to 7 feet and widening of the spillway to accommodate new PMF discharge requirements. Consequently, new monuments were installed in 1988 along the crest and at the right and left abutments. Prior to the 1986-87 raise, crest monuments ran along a straight line alone the crest of the dam similar to other District dams. Instead of positioning the crest monuments along a single straight line, locations of survey monuments installed in 1988 at Anderson Dam alternate from the upstream to downstream side of the crest.

Since July 1988 the District has used Global Positioning Satellite (GPS) methods to survey new crest monuments installed at Anderson Dam after the 1986-87 dam raise.

Before 1988, and the introduction of GPS surveys with the resulting data provided in the form of coordinates (Northings and Eastings), previous transverse data consisted of offset displacements either upstream or downstream relative to the monument line established soon after the dam was constructed.

Survey of monuments at Anderson Dam consists of using GPS techniques with data format in X-Y coordinates (eastings and northings, respectively). Previous survey techniques of the original crest monuments consisted of offset (transverse) displacements either upstream or downstream relative to the monument line established soon after the dam was constructed. These data are calculated from the coordinate data using trigonometric relationships assuming stable reference points away from the dam and located in the right and left abutments. The reference baseline for the transverse displacement calculation uses the coordinates of the end points, assumed to be relatively stable monuments in bedrock immediately right and left of the dam, at the time the survey was first established. It should be noted that the GPS survey (northing, easting, and vector displacements) do not utilize local stable endpoints, but a regional GPS station, and thus produce somewhat different results with respect to points of reference.

For this report, the District decided to update previous survey data as plots of vertical and transverse displacement, which are the same plots used by the District prior to 2006 annual surveillance report (Nelson and Volpe, 2006). This is consistent with survey techniques of the original crest monuments that consisted of measuring offset (transverse) displacements either upstream or downstream. The District converted the newer Global Positioning System (GPS) survey method's CA Zone 3 State Plane coordinates to transverse displacements using trigonometric methods.

The vertical and transverse displacement calculations replace previous plotting methods known as Vertical Displacement Double Difference (DD) and Lateral Displacement Resultant Double Difference (RDD). We are no longer presenting (DD) and (RDD) calculations because we discovered certain limitations in these methods. These include uncertainties as to 1) what lateral displacement directions were being calculated because the RDD method only produces positive values and 2) whether the RDD method could be used to detect all possible deformation scenarios (i.e. right-lateral, left-lateral, compression, extension). The District will assess the possibility of making appropriate changes to the RDD method for use in future annual surveillance reports.

As a consequence of reinstating "vertical" and "transverse" displacement plots we've highlighted survey data collected since the October 2004 report (Nelson and Volpe, 2004) as gray shading on Figures 13 through17.

Vertical survey data is collected and processed following the same methods used previously, traditional closed loop least squares adjusted leveling technique. The results from the leveling adjustment, including the associated errors, are combined in a 3D least squares adjustment with total station angles and distances with GPS measurements.

2.4.1 Dam Crest and Abutment Monuments

The crest monuments generally alternate between the downstream edge and upstream edge of the crest. Data plots have been grouped as either "upstream (U/S) edge" or "downstream (D/S) edge". The location of the surface monuments are shown in Figure 1 (plan view) and Figure 4 (longitudinal section view).

As noted in previous annual surveillance reports, because monument 31 was destroyed during the 2003/2004 boat ramp construction, the new left abutment control endpoint is monument 30, which is used as a reference point to determine local transverse displacements.

2.4.2 Spillway Training Wall Monuments

Three survey monuments are located at the top of the spillway training walls, two on a wall on the left side of the spillway ogee (mons. 14 and 15), and one on a wall on the right side of the ogee (mon. 13), as shown in Figure 1. It should be noted that monument 13, on the right spillway wall, has not been monitored since October 2001 because of difficult access for the surveyors. Also, it recently came to our attention that previous spillway training wall horizontal and vertical survey results may be questionable. Access to the training wall monuments are somewhat blocked by chain link fences that are situated directly over the monuments making it difficult to survey the monuments (see Nelson and Volpe, 2004 for more information).

Because of the difficulty of accessing the monuments positioned at the bottom of a chain link fence, some errors may be introduced in the survey data from the spillway training walls. Even with these limitations this surveillance report provides historic data plots showing vertical displacement of Monuments 14 and 15 in Figure 16.

2.5 Inclinometer Boring

During drilling for DIP from October 19, 2006 through October 27, 2006, the District's contractor installed one in-place inclinometer casing at the crest through the maximum section of Anderson Dam into bedrock. The inclinometer casing is about 266 feet deep and penetrates about 11 feet into the underlying Franciscan Complex melange.

In May and June 2007, after construction of the inclinometer boring, the District collected manual inclinometer readings of the casing orientation (see Section *2.5.1 Manual Inclinometer Probe*). Also, as discussed below in more detail in Section *2.5.2 In-Place Inclinometer Sensors (IPIs)*, on June 10, 2008 the District installed a series of electronic tiltmeter "Little Dipper" in-place inclinometers in the casing to monitor potential deformation of the dam. The ADAS system is currently set up to collect in-place inclinometer data at the same daily interval as the vibrating wire piezometer data. These IPIs data collected to date are considered nonviable. We expect that when ADAS is repaired the system will collect viable IPIs data.

A distinction is made between data from the manual inclinometer probe described in Section *2.5.1 Manual Inclinometer Probe* and data from in-place inclinometers sensors (IPIs) described in Section *2.5.2 In-Place Inclinometer Sensors (IPIs)*. Manual inclinometer probe data are collected periodically by a survey crew after the IPIs are temporarily removed. The probe is a sensitive electronic pendulum that measures deflection of the plastic pipe. IPIs data is collected automatically by ADAS from in-place sensors that remain stationary in the vertical column defined by the inclinometer boring casing.

2.5.1 Manual Inclinometer Probe

As part of routine surveillance of Anderson Dam, the District performed an initial manual inclinometer survey of the inclinometer borings installed during the DIP in 2007 using the District's manual inclinometer probe. The initial manual survey was performed in inclinometer boring 72-9-ASI-1 (IPI9-3) on May 28, 2007. A second manual survey was performed on June 29, 2009. The May 2009 reading is considered erroneous because final depth of the survey only goes to a depth of 230 feet, which is about 36 feet above the bottom of the inclinometer casing at a depth of 266 feet. The final depth of the May 2009 survey data goes to a depth of 264 feet, which is within 2 feet of the bottom. Consequently, the May 2009 reading is considered viable data.

Part of the monitoring plan is to periodically perform additional manual inclinometer probe surveys at Anderson Dam as needed. Special surveys are usually performed following events such as significant earthquakes (earthquakes with moment magnitude values greater than ~5.0, within 20 miles of District dams). Special manual inclinometer probe surveys have not been performed since the initial September 2007 survey.

Part of District procedure is to perform manual surveys as a backup and supplement to the relatively continuous data collected by ADAS from the in-place IPI sensors (discussed in the Section *2.5.2 In-Place Inclinometer Sensors (IPIs)*). However, until issues with the IPIs are resolved, we will routinely use a voltmeter to collect manual field readings. Consequently, the manual probe readings will supplement the manual voltmeter readings periodically collected from the IPIs.

During DIP the District installed inclinometer casing in boreholes that fully penetrate the embankment with the bottom of the casing embedded at least ~10 feet into competent stable bedrock. To measure ground deformation using inclinometers it is critical to have the bottom portion of the casing socketed into bedrock as a stable reference point. The special inclinometer casing is fabricated with continuous longitudinal grooves at the 0°, 90°, 180°, and 270° locations around the perimeter of the casing. When the casing was installed an effort was made to orient one set of grooves known as the A0 and A180 directions (0° and 180°grooves) normal (right-angles) to the axis of the dam crest. It simplifies computation of the resultant direction displacements to orient the casing such that the principal axis is aligned in a direction that will likely experience maximum potential embankment deformation. The second set of grooves known as the B0 and B180 directions (90° and 270°grooves) then align parallel to the crest of the embankment. The A0 direction is the orientation of the "A-axis" or primary axis of two perpendicular inclinometer-casing grooves of the inclinometer casing. The secondary axis is known as the B0 direction of the "B-axis".

It should be noted that readings collected for IPI9-3 in the A0 and B0 groove directions by definition are positive with the A0 direction downstream and the B0 is toward the right abutment.

The District uses an 18-inch long portable inclinometer probe (an extremely sensitive pendulum) to manually survey the verticality of the casing. The initial survey after installation of the casing establishes the initial casing profile. Subsequent surveys are compared to the initial survey so any magnitude and direction of movement at any depth in the casing can be determined. The standard portable inclinometer probe used by the District for surveying the casing is designed to obtain a complete profile by recording and plotting data from the bottom to the top of the casing. During a typical inclinometer survey the probe is lowered to the bottom of the hole. The first reading is collected after the cable is pulled 2 feet above the bottom with subsequent readings taken every 2-foot-length of inclinometer cable as the probe is manually pulled towards the top. Consequently, all readings are relative to the bottom of the boring as a stable reference point. For repeatability, it is critical that readings are collected at specific cable length intervals of 2-feet and do not change during the monitoring program. Two sets of readings are taken at the same depth increments along each set of opposing grooves (A-axis and B-axis). A portable readout or a data logger is used to record the surveys. Readings are collected with an electronic readout box that store readings in solid-state memory that enable the transfer of the data to a computer for processing. The electronically generated data are then entered and manipulated by District Dam Safety Program personnel using applicable software programs.

2.5.2 In-Place Inclinometer Sensors (IPIs)

The single inclinometer boring is located near the maximum section of Anderson Dam (Figure 1 and Figure 3). The original purpose of the IPIs was to monitor gross internal movements of the dam such as those that could occur during a significant earthquake or rapid drawdown of the reservoir.

IPIs were installed in IPI9-3 on June 10, 2008. Six IPIs (9-3-1 through 9-3-6) were installed in inclinometer boring IPI9-3, which was completed to a depth of 266 feet during the DIP drilling from October 19 through 27, 2006. Inclinometer casing was grouted into Franciscan Complex bedrock to depths of ~11 feet in IPI9-3.

For reasons discussed below, the District is not presenting data plots from the in-place inclinometer Little Dipper bi-axial sensors (IPIs) collected by ADAS. Six IPIs are located in inclinometer boring 72-9-ASI-1 (IPI9-3) shown on Table 2 and in Figures 1 (plan view) and 3 (section view). Table 2 summarizes pertinent information on each IPIs including IPIs designation, drill hole designation, sensor depth, sensor elevation, and surface elevation at the top of the inclinometer boring.

Our evaluation of IPIs data from Districts dams with DIP instrumentation (Anderson, Almaden, Calero Main, and Guadalupe Dams) indicates that ADAS hasn't collected viable IPIs data since startup of the system in December 2008. However, the District has been periodically collecting manual field reading.

Consequently, rather than plotting IPIs data from ADAS we are providing IPIs data from the manual field readings in our surveillance reports. We are currently looking at possible remedies for correcting the problems with the IPIs including installing upgraded field modules from the manufacturer. The District anticipates that the problem will be corrected fairly soon, and hopefully, before the next surveillance report. The District will keep DSOD apprised of this effort.

Deflections of the inclinometer casings are measured electronically from a bubble level in the IPIs in arc degrees that are converted to inches of deflection. Also, the IPIs measure deflection over a relatively large distance, typically the distance between one IPI sensor and the IPI sensor located directly above (typically 10 feet to 20 feet), while the manual probe described above (Section *2.5.1 Manual Inclinometer Probe*) measures deflection over a distance of only 2 feet (24 inches). Because of these differences it is difficult to make direct comparisons between data from the IPIs and data from the manual probe. We anticipate that both types of inclinometer measurements should show real casing deflection within the same order of magnitude.

The Applied GeoMechanics model 906 Little Dipper IPIs were placed vertically in each inclinometer boring using fiberglass rods that connect the individual IPIs successively in a vertical column. For inclinometer IPI9-3 the Y-axis of each sensor is oriented upstream/downstream with the +Y axis pointing upstream. The X-axis of each sensor is oriented parallel to the dam axis, with the +X axis pointing toward the left abutment. The Y-axis of the IPIs is equivalent to the A-axis (A0/A180) groove directions established for the manual inclinometer probe and the X-axis is equivalent to the B-axis (B0/B180) groove directions as discussed above in Section *2.5.1 Manual Inclinometer Probe*. The convention of positive and negative directions for the IPIs is different than for the manual inclinometer probe. While +Y is always pointing upstream for IPI9-3, the positive A0 values are downstream, with corresponding positive B0 values toward the left abutment.

2.6 U.S.G.S. and District Strong Motion Accelerometers

U. S. Geological Survey Accelerometers

Six Kinematrics Model SMA-1 strong motion recorders (accelerometers) were installed in 1985 by the U.S. Geological Survey (U.S.G.S). Five accelerometers are installed on the downstream slope and one about 150 feet south-southwest of the crest in the left abutment (see Figure 1). The accelerometers are operated and maintained by the U.S.G.S. District Dam Safety Program Unit personnel request seismic data from the U.S.G.S. if the six instruments have recorded seismic accelerations after significant earthquakes occur in the vicinity of Anderson Dam.

District Accelerometers

An Altus Etna strong motion accelerometer manufactured by Kinemetrics is securely mounted on the floor of the blockhouse on the crest of the dam. The purpose of the accelerometer is to record accelerations in the vicinity of the dam in the event of an earthquake. The accelerometer continuously monitors ground acceleration and compares current acceleration levels to preset thresholds. When an excursion of the threshold acceleration value is detected, ADAS notifies the District with an alarm that the threshold condition (typically 0.03 g) was exceeded. No alarms were triggered during the period of this report.

ADAS is set up to query the accelerometer for possible data at a 10-minute frequency during every 24 hour period. In addition, ADAS routinely retrieves data from vw piezometer and IPIs every 10 minutes. These frequent-interval data are temporarily stored in flash cards in the ADAS instrumentation center located onsite in the block house located on the crest of Anderson Dam. These data are only retrieved manually by District Dam Safety Program personnel after they have been alerted to an alarm condition of the accelerometer. Data flash cards are retrieved from the dam and taken back to the office, where all pertinent ADAS data recorded at 10-minute intervals are then compiled and analyzed.

3.0 SURVEILLANCE DATA

3.1 Annual Reservoir Fluctuation

Figure 5 shows the detail of reservoir fluctuation from 2006 through most of calendar year 2009 with gray shading that denotes recent data during the current surveillance period from January 2009 to the present. The maximum reservoir excursion for 2009 was el. 602 feet (~26 feet below spillway lip el.) on March 9 & 10, 2009. Recent prior maximum reservoir excursions in 2006, 2007, and 2008 were el. 628 feet, el. 612 feet, and el. 613 feet, respectively. The last time Anderson Reservoir spilled was in April 2006 (Nelson and Volpe, 2006). The preponderance of rainfall for any given calendar year typically occurs during January through April/May. For the last 3 years the San Francisco Bay Area has been experiencing a drought, with below normal rainfall. During the drought the reservoir response has been significantly muted as shown in Figure 5.

A DSOD ordered reservoir restriction for Anderson Reservoir was implemented and monitored by District Operations and Planning Unit beginning in January 2009. On December 29, 2008 the District submitted a copy of the AMEC Geomatrix Preliminary Seismic Stability Evaluation (AMEC, 2008) of Anderson Dam to both DSOD and FERC informing them of its findings and our resulting action to implement an operation restriction to keep the reservoir below elevation 617.2 ft NAVD, for an added 10.6 feet below spillway ogee elevation for a total reservoir freeboard of 30 feet. After further discussions with DSOD in early January 2009, DSOD required that the District provide an additional 10 feet of operating restriction, which amounts to an operating restriction of ~20 feet below spillway ogee elevation for a total operating freeboard of ~40 feet. These restrictions were first ordered by DSOD in a letter dated January 26, 2009.

As mentioned above, Anderson Reservoir is currently restricted to elevation to 607.3 feet which is 20 feet below the spillway lip elevation (627.8') based on NAVD 1988, or ~73% reservoir capacity, which provides approximately 40 feet of total freeboard (NAVD 1988 is 2.8' greater than NGVD29). Since January 2009, Anderson Reservoir did not exceed the restriction elevation of 607.3 ft. As shown in Figure 5 the maximum reservoir excursion since January 2009 was ~el. 602.0 ft or about 5 feet below the restriction on March 9 and 10, 2009.

As shown in Figure 5, during most of calendar year 2009 Anderson reservoir experienced predominantly falling water levels except for a minor reservoir rise during early to middle March 2009. Anderson Reservoir began the calendar year at about el. 598 feet, or ~30 feet below spillway crest (el. 627.8). By early March 2008, the reservoir had gained about 4 feet and had reached its high elevation of the year of 602 feet on March 9 and 10. During this period the reservoir rose at a rate of approximately ~0.4 ft/day. From early March 2009 through late April 2009, reservoir levels dropped only 8 feet at a rate of ~0.17 ft/day. For the remainder of 2009 the reservoir continued to drop an additional 17 feet at a rate of ~0.07 ft/day to an elevation of 580 feet at the end of 2009.

3.2 Piezometers

Figure 6 shows both pneumatic and open well piezometric levels, reservoir levels, and monthly rainfall data for the most recent 10 year period from January 1999 through October 2009. Table 3 and the gray area of Figure 6 show data since our 2009 report (Nelson and Volpe, 2009).

The piezometer data presented in Figure 6 is in the form of piezometric surface elevation (PSE) vs. time for each piezometer. The PSE is defined as the sum of the piezometer tip elevation (feet) and the hydraulic pressure head (feet).

Overall, the data indicates that fluctuations in these piezometric levels show a much muted response to fluctuations in reservoir level. Pneumatic piezometers PPA-1 and PPA-2, located in the lower portion of the central clay core, consistently show minor variations in piezometric elevations under a wide range of reservoir fluctuations.

The pneumatic piezometer data appear to be providing reliable and consistent data during the entire surveillance period.

As shown in Figure 6, since installation, open well OW-1 (located about 50 feet from the downstream toe of the dam) has consistently ranged between ~elev. 403.7 feet and 406.6 feet, or ~10 feet to 13 feet below ground surface. For 2009, piezometric elevations in OW-1 were consistently ~elev. 406 feet, which corresponds to a depth of ~10 ½ feet below ground surface.

Since installation in April and May 2009, there are only 2 data points for PSE values in new open wells OW-2 and OW-3. Trends of the phreatic surface in these wells have not been established.

3.2.1 Preliminary Findings of New Vibrating Wire Piezometer Responses

The piezometer data presented in Figures 7 through 11 are in the form of piezometric surface elevation (PSE) vs. time for each piezometer. The PSE is defined as the sum of the piezometer tip elevation (feet) and the hydraulic pressure head (feet).

The maximum Anderson Reservoir elevation since installation of the VW piezometers was about 613 feet on April 9, 2008, which is about 14 feet below the spillway lip.

3.2.2 Preliminary Findings of New Piezometer Results

There are several pertinent observations based on piezometer information to date. These are summarized below.

- Based on the muted response of core piezometers as indicated in Figures 7, 8, and 9, hydraulic pressures being imposed by the dam are being safely dissipated by head losses through the core in a safe and effective manner. This is evident by 16 piezometers located within the U/S Zone 2 and D/S Zone 3 core sections (see Table 1) that indicate no significant variations in hydraulic head losses across the entire width or length of the dam.

- Except for piezometers in the left abutment (72-9-18 & 72-9-31) and right abutment (72-9-25 & 72-9-27) (see discussion below), the majority of the foundation piezometers are measuring only a fraction of the total possible pressure head at various locations beneath the core of the dam (Figure 10). This supports the effectiveness of the foundation preparation including the removal of surficial soils (i.e. alluvium and colluvium) beneath the core during construction and the fact that the vast majority of the clay core rests on and is in direct contact with either predominantly competent Franciscan Complex bedrock or semi-consolidated Santa Clara Formation sediments.

- The left and right abutment piezometers (72-9-18, 72-9-31, 72-9- 25, and 72-9-27) in bedrock (Franciscan Complex and possibly Santa Clara Formation) appear to have relatively high PSE values based on their relatively high tip elevations (580 ft, 600 ft, 500 ft, and 585 ft, respectively) and the likelihood these piezometers are located in bedrock that may be slightly more permeable than the clay core. Piezometer 72-9-18 is essentially dry with a PSE value close to the tip elevation; Piezometer 31 has PSE values ~2 ft higher than the tip elevation; Piezometer 72-9-25 hasn't been recording data since February 2009 with a last PSE value ~64 feet higher than tip elevation; and Piezometer 72-9-27 has PSE values ~2 ft higher than the tip elevation. Piezometer 72-9-31 is noteworthy because regardless of how much the reservoir drops, the minimum PSE stays at about elev. 602 ft. Currently, PSE values in 72-9-31 are at ~elev. 601.9 ft while reservoir elevation is ~elev. 581 ft, indicating that the phreatic level in 72-9-31 is ~20 ft higher than the reservoir. The tip of piezometer 72-9-31 is located at a relatively high elevation (~600 ft) in the left abutment. This higher pore pressure response relative to reservoir levels likely reflects the concept of storage retention or field capacity when a porous media is drained.

- Based on the results of two upstream transition zone piezometers (72-9-6 and 72-9-15), there is essentially no loss (dissipation) of reservoir head through the upstream rockfill shell and transition zone, which means that the full reservoir hydrostatic head is acting along the upstream sloping face of the core. This performance is expected because the upstream rockshell and transition zones are very permeable.

- Four piezometers were likely installed within the downstream transition zone, including 72-9-7 and 72-9-8 in Section A-A (Figure 2), and 72-9-16 and 72-9-17 in Section B-B' (Figure 3). These four piezometers are all measuring PSE values essentially at their respective piezometer tip elevations indicating that the phreatic surface in these piezometers is below the tip (i.e. dry holes), which indicates that the downstream transition zone and overlying rockfill zone are essentially dry. These results indicate that the transition zone is effectively capturing the phreatic surface as it exits the downstream face of the core.

- Piezometers 72-9-28 and OW-1 are both located in the downstream foundation, with OW-1 actually located about 50 feet beyond the downstream toe very close to the maximum section. These two piezometers have a drop in maximum PSE value of about 4.7 feet over a horizontal distance of about 240 feet. This computes to a relatively low horizontal seepage gradient of about 0.02 (4.7'/240') in the downstream toe area.

3.3 ADAS Data Gaps

In this section we discuss methods used to present data gaps and summarize actual ADAS related data gaps. Since ADAS collects essentially continuous readings (4 times daily during December 2008 to June 2009; 1 time daily from June 2009 to the present), we have established a procedure to delineate significant data gaps. For this and all future surveillance reports, we set up the plotting software (Grapher software) to show data gaps, which are defined as the absence of recorded instrument data for a period greater than about 1 week.

Ideally, the ADAS system is programmed to collect data daily. However, there are occasional gaps in the data that occurs periodically for unknown reasons and involves a field data terminal (FDT) that will not record data for significant intervals until a time is reached when data is again recorded by the FDT. We have observed this type of periodic-self-correcting behavior in the District's Lenihan Dam's ADAS since the system was implemented in 1998-2000. Our experience suggests this seems to be an inherent behavior of ADAS systems, at least at District facilities.

The plotting program we use (Grapher) can be set up two ways to depict the surveillance data. One setting option to depict missing data, known as "continuous plot", provides a relatively straight line interpolated through the available data even when there are gaps in the data. This setting option has been used in all prior surveillance reports as a suitable method to plot surveillance data because original piezometer and weir data are collected roughly on a monthly basis. A second "discontinuous plot" setting option more accurately depicts gaps in the data by not interpolating a line through the "missing data". The "discontinuous plot" setting option was used in Figures 7 through 11 to show significant data gaps in the vibrating wire piezometers as discussed below in more detail.

The most significant gap ranges from July 2008 to December 2008 (~ 5 months), which includes all vw piezometers except 2 piezos (72-9-01 and 72-9-02). This corresponds to the period when the District was constructing the ADAS system. Fortuitously, this timing of ADAS construction coincided with a period when Anderson Reservoir was relatively low and decreasing its capacity during the dry part of the year. Consequently, the significant data gap corresponds to the dry period of the year, a relatively non-critical time when reservoir and piezometer levels were low.

Another significant gap includes 8 vwps in the central core (72-9-09B, 72-9-10, 72-9-11, 72-9-12, 72-9-13, 72-9-22, 72-9-23, & 72-9-24) with the gap starting from August 27, August 30, or September 29, 2009 and continuing to the present (~4 to 5 months). In addition, no data has been collected by ADAS from piezometer 72-9-25 since February 23, 2009. District is making an assessment of this situation to determine if the problem is related to ADAS components or to problems with the instruments themselves. We will keep DSOD apprised on the status of the results of this evaluation.

It should also be noted that there are several subtleties to the plotted piezometer data in Figures 7 through 11. One subtlety is that there are two general data sets related to the July 2008 to December 2008 gap mentioned above. One data set designated as "the early data set" from January 2007 to July 2008 represent manual piezometer data collected at intervals ranging from daily to ~1 to 4 times a month after the DIP drilling and prior to implementation of ADAS. The second "later data set" represents piezometer readings collected daily by ADAS once it was completed from December 2008 to the present. As mentioned above, there is a significant ~5 month gap in surveillance data between these two dates.

Another subtlety is the use of lines passing through the data and the number of data points used to define the data of each piezometer plot. For each data set a relatively continuous line is shown passing through all collected data points. However, the number of data symbols on the plots for each data set is depicted differently due to the relative amount of data gathered. Since there are relatively fewer data points of the "early data set" (pre-ADAS) each symbol represents a single data point. Because the "later data set" (post-ADAS) contains multiple daily readings we have set the plotting software to depict individual data symbols only every 40th data point in order to reduce clutter of multiple overlapping data symbols. Consequently, because the lines represent more data of the "later data set', there will be bends in the lines depicting changes in instrument response regardless of whether or not a symbol is present at a particular bend. As noted elsewhere, the District reduced the sampling frequency on June 10, 2009, from 4 points collected daily to 1 point collected daily. Thus, the later data set contains an additional subtlety in that there are more data points prior to June 10, 2009 and less points after this date.

3.4 Spillway Underdrain Flow

Starting with this report we are only providing historic data plots covering the last 10 years (since ~ 1999). Spillway underdrain flow data was formerly collected using a flow meter. This form of data was last collected in 1998 when weirs No. 1 and No. 2 were constructed to replace the underdrain flow meter. Consequently, we no longer provide data plots of the former underdrain flow, but only plots of the weir discharge data. Table 4 and Figure 12 show monthly rainfall and data from weirs No. 1 and No. 2 from April 2000 through October 2009.

During 2009, the combined flow from the weirs ranged from a low of ~30 gpm (June 2009) to a high of ~58 gpm measured March 2009. The overall flow is relatively small during the period of this surveillance report due to relatively low reservoir levels as discussed in Section *3.1 Annual Reservoir Fluctuation*.

3.5 Crest and Spillway Training Wall Monuments

For the current surveillance period, the monuments were surveyed on September 8, 2009. As stated above, starting with this surveillance report we are no longer including the RDD method due to some shortcomings we've discovered (see Section *2.4 Survey Data*), but are using the old transverse displacement method, that shows movement in the transverse (i.e. upstream/downstream) directions only. As a consequence of reinstating "vertical" and "transverse" displacement plots we've highlight survey data plots new since the December 2006 report (Nelson and Volpe, 2006) as gray shading in Figures 13 through17.

The terrestrial survey performed at Anderson Dam is based on using conventional GPS techniques to establish current coordinates (northing and easting) for the local bench mark (Monument 393) used for the survey. This is accomplished by using the known coordinates of benchmarks located reasonably close (typically within 1 to 2 miles) to the site.

Net vertical and transverse displacements since the last surveillance report is shown at the bottom of each data set on Table 5. Since 1 survey (September 2009) was performed during this reporting period, Table 5 summarizes vertical displacement and local transverse displacement from the previous reporting period survey (October 2008) to the present (September 2009).

The vertical and transverse data presented in Figures 15 and 16, and on Table 5, for Anderson Dam monuments, indicate minimal horizontal and vertical displacements (less than 0.01 ft in the vertical plane and 0.01 in the horizontal plane) have occurred during this reporting period. These small displacements indicate that only minimal, normal displacements of the dam have occurred during this reporting period with no obvious trends.

3.6 Manual Inclinometer Data

As discussed in Section *2.5.1 Manual Inclinometer Probe*, as part of routine surveillance of Anderson Dam, the District performed an initial manual inclinometer survey of the inclinometer borings installed during the DIP in May 2007 using the District's manual inclinometer probe. A second manual survey was performed on June 29, 2009. The May 2009 reading is considered erroneous because final depth of the survey only goes to a depth of 230 feet, which is about 36 feet above the bottom of the inclinometer casing at a depth of 266 feet. The final depth of the May 2009 survey data goes to a depth of 264 feet, which is within 2 feet of the bottom. The May 2009 reading is considered the only viable survey data. At least two surveys are needed to show a meaningful plot; these should consist of an initial survey and subsequent survey(s) to compare with the initial survey. Thus we are not including inclinometer probe data plots in this surveillance report.

3.7 In-Place Inclinometer Sensor Data

As discussed in Section *2.5.2 In-Place Inclinometer Sensors (IPIs)*, our evaluation of IPIs data from Districts dams with DIP instrumentation (Anderson, Almaden, Calero Main, and Guadalupe Dams) indicates that viable data is not being collected by ADAS. We decided not to provide plots of IPIs data from ADAS in our surveillance reports. However, as discussed below we are including IPIs data collected manually in the field using a voltmeter.

Table 2 shows the depths and corresponding elevations of the in-place inclinometer sensors (IPIs). The following equation from the Little Dipper User manual (Applied GeoMechanics) is used by ADAS to convert arc-degrees readings from the IPIs to inches lateral displacement:
$d = L*\sin\theta$, where d = lateral displacement, L = distance between sensors (~10 feet, 20 feet, or 25 feet converted to inches) and θ = arc degrees.

As a backup of the data collected by ADAS, we collected and plotted manual readings of the IPIs taken in the field with a voltmeter and a battery to power the IPIs. For the six IPIs in IPI9-3 the District collected manual field readings initially on September 16, 2008 when ADAS was being constructed (~3 months prior to final implementation of ADAS), and more recently on December 22, 2009. Four data points for most of the IPIs are shown as solid lines on Figures 18 and 19. The manual data indicates fairly consistent readings that have not varied significantly during the last ~15 months (Sept 2008 to December 2009). One sensor (IPI9-3-6) appears to be providing nonviable data since July 27, 2009 (Figure 18). For the most part, the manual readings consistently show larger absolute volt reading values (negative and positive) than the ADAS readings. This strongly supports our belief that the ADAS readings at all DIP dams are not currently viable and should not be used to evaluate actual dam deflection.

We will continue to analyze the IPIs data using a voltmeter to collect manual field reading, but will discontinue analyzing IPIs data from ADAS until the problems are rectified. As more IPIs data is gathered using a voltmeter, we will continue to evaluate the utility of the IPIs sensors to determine if they can provide sufficient reliability and accuracy to warrant continued use. We will plan on providing conclusions and recommendations by the time the next surveillance report is submitted.

We will continue to monitor field manual voltmeter IPIs data for any trends and we will keep DSOD apprised.

4.0 SIGNIFICANT AND NOTEWORTHY SEISMICITY

There were no earthquakes greater than ML 5.0 during the reporting period from January 2009 through December 2009. Significant earthquakes are defined as having approximate magnitudes greater than M_L 5.0. Noteworthy earthquakes, defined as having approximate magnitudes less than M_L 5.0 but greater than about 4.0 occurred at four locations in the San Francisco Bay Area, during the reporting period from January 2009 through December 2009 (Figure 20) with the following date, magnitude, distance and direction from Anderson Dam.

1. On December 21, 2008, a magnitude 4.0 earthquake occurred about 36 miles southeast of the dam.
2. On January 20, 2009, a magnitude 3.9 earthquake occurred about 38 miles southeast of the dam
3. On March 30, 2009, a magnitude 4.3 earthquake occurred about 8 miles north of the dam
4. On September 6, 2009, a magnitude 4.0 earthquake occurred about 25 miles southeast of the dam.

5.0 ACCELEROMETERS

There are 6 accelerometers at the site (5 on the dam, and one on the left abutment knob) which are owned, maintained and monitored by USGS. There are no accelerometer data to report since the October 31, 2007 Alum Rock earthquake event (2007 Annual report, Nelson and Volpe, 2008).

A new strong motion accelerometer was recently installed on the crest of the dam in association with ADAS. This new instrument will be maintained by the District as discussed in Section *2.6 U.S.G.S. and District Strong Motion Accelerometers*.

6.0 VISUAL INSPECTIONS AND MAINTENANCE ISSUES

The following significant inspections were performed during the period of this report include:

1. May 19, 2009 Joint annual inspection with DSOD and FERC; District (D. Hook, B. Baker, R. Jacobs), FERC Engineers (B. O'Keeffe & E. Salire), and DSOD engineers (A. Ordoubigian, R. Bowlus) performed an annual inspection of Anderson Dam and appurtenant structures.
2. October 6, 2009 annual inspection with DSOD including District (D. Hook, B. Baker, R. Jacobs, & J. Nelson), and DSOD engineer (R. Bowlus) performed an inspection of Anderson Dam and appurtenant structures.
3. November 10 and 11, 2009 inspection of sloping intake structure by licensed commercial diver (Underwater Resources Inc.)
4. November 12, 2009 outlet inspection by DSOD (R. Bowlus) and District (D. Hook, J. Crowley, and R. Jacobs), GEI Consultants (G. Bureau), URS representing AMEC (C. Smith).

6.1 Other District Inspections

This additional safety inspection by District staff focused on maintenance and monitoring issues.

1. December 2, 2008, Work on ADAS including identification of swapped vwp wires and replacement of bad modules by District (B. Baker & P. Khosraviani), and Geomation (J. Klebba)
2. February 13, 2009, Work on ADAS by District personnel (B. Baker & J. Nelson)
3. February 19, 2009, Site visit to assess alignment and construction aspects of drill rig access roads for SSE1A drilling by Dam Safety Program staff (M. Mooers & J. Nelson), other District water shed personnel, and AMEC personnel
4. February 26, 2009, Site visit to observe features in the vicinity of the 1997 Anderson spill breach for GEI work on Leroy Anderson Dam FERC Part 12D Safety Review Task 6.5, Assessment of Spillway Channel "Levee" by District (J. Nelson) and GEI (B. Cole)
5. March 12, 2009, Site visit to observe progress of assess road construction for SSE1A drilling by District (M. Mooers & J. Nelson), AMEC/Geomation personnel (C. Johnson and Anne Marie), Boart Longyear driller (D. Osterberg) and other District water shed personnel
6. March 16, 2009, Site visit to observe fault related features of Range Front Thrust fault (RFTF) in vicinity of D/S toe of dam exposed in old Quarry south of Dam and north of dam in a ravine by Dam Safety Program staff (M. Mooers & J. Nelson), William Lettis Associates (WLA) geologists K. Kelson & R. Turner, and AMEX/Geomatrix geologists T. Compton, C. Slack, C. Johnson)
7. Multiple SSE1A related site visits including drilling and potential fault study sites on
   a) 3/19/09 District (D. Hook, M. Mooers & J. Nelson), DSOD personnel (M. Pi, R. Burns, J. Lessman, C. Dorsey), FERC personnel (E. Salire & L. Holden), AMEC (M. Ryan, T. Crampton, F. Makdisi, & C. Slack) and TRB (Professor R. Seed)
   b) 3/24/09 District (M. Mooers & J. Nelson),

   c) 3/30/09 District (B. Baker & J. Nelson),
   d) 4/1/09 District (J. Nelson, M. Mooers, & D. Hook), FERC (B. O'Keeffer & E. Salire) TRB (R. Seed), DSOD (W. Fraser, R. Bowlus, C. Dorsey) AMEC (M. Ryan, F. Makdisi, C. Slack & C. Johnson) and WLA (R. Turner),
   e) 4/8/09 District (M. Mooers, J. Nelson),
   f) 4/9/09 visit to fault study site Rosendin Pond District (M. Mooers, D. Matthews, S. Akin, N. Merrill, & J. Abel),
   g) 4/16/09 District (J. Nelson & M. Mooers), AMEC (M. Ryan, T. Crampton, & F. Makdisi), DSOD (W. Fraser, J. Lessman, D. Gutierrez, A. Ordoubigian, R. Bowlus, & C. Dorsey) and FERC (G. Maloney),
   h) 4/21/09 discussed site faulting and geology at office of Pacific Geotechnical Engineering (PGE, who mapped geology of site and Morgan Hill) and later performed site visit with District (J. Nelson), AMEC (T. Crampton & C. Slack) and PGE geologists (R. Fisher & J. Feltman),
   i) 4/24/09, District (J. Nelson) and AMEC (T. Crampton & C. Slack) made numerous observations of RFTF and other geologic relationships north of Anderson Dam
   j) 5/12/09 District (D. Hook, J. Hillman, J. Nelson, and watershed personnel), AMEC (F. Makdisi, M. Ryan, C. Slack, C. Johnson, WLA (R. Turner & G Kanetten), DSOD (C. Dorsey, J. Lessman, M. Pi, & A. Prakash) to observe excavated pit at D/S toe of dam
   k) 6/23/09 District (M. Mooers, J. Nelson), DSOD (J. Lessman & C. Dorsey), and AMEC (M. Ryan, T. Crampton, C. Slack, & C. Johnson)
8. June 1, 2009, site visit to Turner property (potential fault study site) for SSE1A fault study to observe site conditions with District (D. Matthews, S. Akin, and J. Nelson), AMEC (T. Crampton & C. Slack), and WLA (J. Pearce)
9. July 27, 28, and 29, 2009, Work on ADAS including replacement of bad modules by District (B. Baker & J. Nelson), and Geomation (P. Klammer & J. Klebba)
10. November 2, 2009, site visit to SSE1A fault study site Turner property to observe environmental site conditions with District (D. Matthews, N. Merrill, C. Lenihan, and J. Nelson) and District interns (K. Smith and S. De Mers)

7.0 SURVEILLANCE PROGRAM

The District will continue with the current operating procedures and scheduled surveillance plans. Pneumatic and open well piezometers will be read monthly, crest and spillway training wall monuments will be surveyed annually, and spillway underdrain flows will be measured at the two weirs at least monthly. ADAS instrumentation (vibrating wire piezometers and in-place inclinometer sensor) will be read daily. In addition, site inspections and monument surveys will be conducted after a significant earthquake or other potentially disruptive activity. While most of the instruments are in good working order, some ADAS related problems exist, which the District will address in 2010. Aside from efforts to repair ADAS and IPIs issues, we do not anticipate major replacement or repair work in 2010.

8.0 OTHER INFORMATION

8.1 Recent Engineering Analyses

The 2006/2007 GSSP DIP field investigation confirmed that the transition zones are located between the impervious core and the upstream and downstream rockfill zones and consist of intermediate-graded materials between these two units (core and rockfill zones). Additional work to refine the geotechnical aspects of the transition zones was performed by GEI Consultants (2009e).

AMEC is currently performing a detailed seismic safety evaluation (SSE1A) of Anderson Dam with a final report due by December 31, 2010.

9.0 CONCLUSIONS

AMEC's 2008 preliminary report, based on limited geotechnical data, indicated a potentially inadequate factor of seismic safety for Anderson Dam (AMEC, 2008). In response to the findings of that report the District 1) implemented an operating restriction, 2) accelerated the schedule for completing a full seismic stability evaluation (SSE1A), and 3) provided outreach to downstream stakeholders.

The surveillance data from Anderson Dam and the District's field observations confirm acceptable performance of the dam for the period of this report, with the dam showing normal responses to the environment, aging process, and external events. The District will continue with the current monitoring program and safety inspections, and will keep DSOD informed of any significant changes pertaining to the surveillance or performance of Leroy Anderson Dam.

Although there were no major incidents or changes at the dam during 2009, an operating restriction for Anderson Reservoir was implemented under the direction of the Division of Safety of Dams and monitored by District Operations and Planning Unit beginning in January 2009. This operating restriction was implemented to provide an added margin of safety in response to preliminary seismic stability results for Anderson Dam. Except for the new operating restriction at Anderson Reservoir of ~40 feet total freeboard, there are no substantive changes in dam or reservoir response compared to previous years.

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Table 1
Locations of Vibrating Wire Piezometers
Anderson Dam

Embankment Piezos

Downstream Core Zone 3	Tip Elev. (ft)	Surface Elev. (ft)
72-9-02*	480	647
72-9-03*	531	647
72-9-04*	580	647
72-9-05	484	631
72-9-10*	430	647
72-9-11*	480	647
72-9-12*	530	647
72-9-13*	580	647
72-9-20	550	647
72-9-22*	450	647
72-9-23*	500	647
72-9-24*	550	647
72-9-26	550	647
72-9-29*	444	614
72-9-30*	490	614
Upstream Core Zone 2	Tip Elev. (ft)	Surface Elev. (ft)
72-9-14	470.0	630.0

Transition Zone

Downstream	Tip Elev. (ft)	Surface Elev. (ft)
72-9-07	557	619
72-9-08	518	602
72-9-16*	539	614
72-9-17	421	583
Upstream	Tip Elev. (ft)	Surface Elev. (ft)
72-9-06	587.0	631
72-9-15	587.0	630.0

Bedrock Foundation

Foundation	Tip Elev. (ft)	Surface Elev. (ft)
72-9-01	453	647
72-9-9B	382	647
72-9-18	580	647
72-9-19	516	647
72-9-21	400	647
72-9-25	500	647
72-9-27	585	647

Alluvial/Colluvial Foundation

Foundation	Tip Elev. (ft)	Surface Elev. (ft)
72-9-28	405	486.0
72-9-31*	600	647.0

Note:
1) * = piezometer installed using grout-in methods (see text)
2) all other piezometer installed using sand-pack methods (see text)

Table 2

Locations of In-place Inclinometer Sensors (IPIs)

Leroy Anderson Dam

Crest Inclinometer IPI9-3 (boring 72-9-AS1)				
IPI Designation	**X-axis & Y-axis**	Spacing between sensors (ft)	Sensor Depth (ft)	Sensor Elev. (ft)
IPI9-3-1	9-3-1X	36.5	36.5	610.5
	9-3-1Y	"	"	"
IPI9-3-2	9-3-2X	21.5	58	589.0
	9-3-2Y	"	"	"
IPI9-3-3	9-3-3X	21.5	79.5	567.5
	9-3-3Y	"	"	"
IPI9-3-4	9-3-4X	21.5	101	546.0
	9-3-4Y	"	"	"
IPI9-3-5	9-3-5X	21.5	122.5	524.5
	9-3-5Y	"	"	"
IPI9-3-6	9-3-6X	51.5	174	473.0
	9-3-6Y	"	"	"

note:

1) sensor spacing includes length of fiberglass connector rod and length of sensor

2) +Y axis is pointing upstream and +X axis is pointing to the left abutment

3) Boring surface elevation = 647 ft

TABLE 3
Recent Piezometric Data
Leroy Anderson Dam)

Date	Reservoir Level (ft)	PPA-1	PPA-2	OW-1	OW-2	OW-3	Monthly* Rainfall (in)
			Piezometric Surface Elevation (ft)				
11/13/08	598.50	577.47	498.67	405.78	---	---	1.69
12/17/08	598.00	577.36	497.63	405.59	---	---	0.75
1/14/09	597.70	577.24	502.04	405.59	---	---	1.30
2/11/09	597.10	576.09	502.46	405.78	---	---	3.94
3/18/09	601.80	575.49	501.56	406.37	---	---	5.75
4/21/09	596.00	576.30	503.17	406.40	NR	---	0.47
5/14/09	593.90	576.87	500.40	405.78	NR	NR	0.35
6/9/09	593.40	NR	NR	NR	407.20	411.60	see below
6/18/09	593.20	575.72	498.09	405.52	NR	NR	0.00
7/15/09	591.80	NR	NR	NR	NR	NR	0.00
8/15/09	590.30	NR	NR	NR	NR	NR	0.00
9/15/09	587.90	NR	NR	NR	NR	NR	0.24
10/15/09	585.60	NR	NR	406.34	406.10	411.60	5.55
11/17/09	582.50	NR	NR	406.24	406.10	411.56	0.20
12/22/09	579.90	NR	NR	405.88	405.90	411.50	2.24

Notes:

1) Piezometer data is Piezometric Surface Elevation (PSE in feet)
2) PSE = pressure head (ft) + elevation head (ft)
3) basis of elevations is NAVD 1988 - values in this table are 2.8 feet higher than NGVD 1929
4) NR = no readings collected; --- = well not present to take readings
5) OW-1 installed 8/5/03, OW-2 installed April 30, 2009, and OW-3 installed May 1, 2009

TABLE 4

Recent Weir Discharge Data – Spillway Underdrains

Leroy Anderson Dam

Date	Reservoir	Underdrain	flow (gpm)	Total flow
11/13/2008	598.50	46.20	6.29	52.49
12/17/2008	598.00	46.20	4.94	51.14
1/14/2009	597.70	38.60	6.29	44.89
2/11/2009	597.10	42.70	3.59	46.29
3/18/2009	601.80	54.30	3.59	57.89
4/21/2009	596.00	38.60	9.43	48.03
5/14/2009	593.90	26.00	6.29	32.29
6/18/2009	593.20	26.00	3.59	29.59
7/15/2009	591.80	NR	NR	NR
8/15/2009	590.30	NR	NR	NR
9/15/2009	587.90	NR	NR	NR
10/15/2009	585.60	12.60	0.45	13.05
11/17/2009	582.50	9.43	0.90	10.33
12/22/2009	579.90	9.43	1.80	11.23

Notes: 1) Weir No. 1 collects flow from the central portion of spillway
2) Weir No. 2 collects flow from the left side of the spillway
3) NR - data not recorded

TABLE 5
Vertical and Local Transverse Data - Crest and Abutment Monuments
Leroy Anderson Dam

Date	Cumulative Monument Vertical Displacement (feet) (since 1988)															
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
12/11/1998	0.02	-0.07	-0.06	-0.24	-0.18	-0.31	-0.27	-0.21	-0.34	-0.16	-0.14	-0.07	-0.02	-0.01	0.01	-0.01
12/3/1999	0.01	-0.07	-0.07	-0.25	-0.19	-0.31	-0.27	-0.21	-0.34	-0.16	-0.14	-0.08	-0.03	-0.01	0.01	0.00
11/28/2000	0.02	-0.07	-0.07	-0.26	-0.19	-0.33	-0.28	-0.23	-0.35	-0.18	-0.15	-0.08	-0.03	-0.02	0.00	0.00
10/18/2001	0.01	-0.07	-0.08	-0.26	-0.20	-0.33	-0.29	-0.23	-0.36	-0.18	-0.15	-0.08	-0.03	-0.02	0.01	-0.01
10/15/2002	0.01	-0.07	-0.09	-0.27	-0.21	-0.34	-0.30	-0.23	-0.36	-0.19	-0.15	-0.09	-0.02	-0.01	0.01	0.00
11/4/2003	0.01	-0.08	-0.09	-0.28	-0.22	-0.36	-0.31	-0.24	-0.37	-0.20	-0.16	-0.08	-0.03	-0.01	0.01	NR
10/15/2004	0.05	-0.04	-0.05	-0.25	-0.18	-0.32	-0.27	-0.21	-0.33	-0.15	-0.12	-0.04	0.01	0.03	0.06	NR
10/15/2004	0.05	-0.04	-0.05	-0.25	-0.18	-0.32	-0.27	-0.21	-0.33	-0.15	-0.12	-0.04	0.01	0.03	0.06	NR
11/1/2005	0.06	-0.02	-0.03	-0.22	-0.16	-0.30	-0.26	-0.20	-0.32	-0.14	-0.10	-0.03	0.02	0.04	0.06	NR
10/31/2006	0.06	-0.02	-0.03	-0.22	-0.16	-0.31	-0.26	-0.19	-0.32	-0.14	-0.10	-0.03	0.02	0.04	0.06	NR
11/7/2007	0.05	-0.02	-0.03	-0.22	-0.16	-0.31	-0.26	-0.20	-0.33	-0.15	-0.11	-0.03	0.02	0.04	0.06	NR
10/9/2008	0.04	-0.03	-0.03	-0.23	-0.16	-0.31	-0.27	-0.20	-0.33	-0.15	-0.11	-0.03	0.02	0.04	0.06	NR
9/8/2009	0.04	-0.01	-0.03	-0.22	-0.17	-0.31	-0.27	-0.20	-0.33	-0.15	-0.10	-0.03	0.03	0.05	0.06	NR
change in disp.	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	NR
10/08 to 9/09		Average change since last survey		=			0.00	or 0.0"								

TABLE 5
Vertical and Local Transverse Data - Crest and Abutment Monuments
Leroy Anderson Dam

Date	Cumulative Dam Crest Monument Local Transverse Displacement (feet) (since 1988)															
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
12/10/1998	0.00	-0.08	-0.06	-0.16	-0.09	-0.18	-0.05	-0.12	-0.18	-0.01	-0.05	0.04	0.00	-0.02	0.00	-0.01
12/3/1999	0.00	-0.05	-0.01	-0.14	-0.06	-0.18	-0.05	-0.13	-0.18	-0.02	-0.06	0.04	-0.01	-0.01	0.00	-0.01
11/28/2000	0.00	-0.04	0.01	-0.13	-0.06	-0.17	-0.05	-0.14	-0.18	-0.02	-0.06	0.04	0.00	-0.02	0.00	0.00
10/18/2001	0.00	-0.04	0.01	-0.12	-0.05	-0.16	-0.04	-0.12	-0.16	0.00	-0.05	0.05	-0.01	-0.02	0.00	-0.01
10/15/2002	0.00	-0.03	0.01	-0.10	-0.03	-0.14	-0.02	-0.11	-0.15	0.01	-0.04	0.06	0.00	-0.01	0.00	-0.03
11/4/2003	0.00	-0.03	0.02	-0.12	-0.02	-0.14	-0.02	-0.11	-0.17	-0.02	-0.06	0.06	-0.02	-0.01	0.00	NR
10/15/2004	0.00	-0.04	0.02	-0.10	-0.02	-0.15	-0.01	-0.10	-0.17	0.03	-0.04	0.06	0.00	-0.03	0.00	NR
10/15/2004	0.00	-0.04	0.02	-0.10	-0.02	-0.15	-0.01	-0.10	-0.17	0.03	-0.04	0.06	0.00	-0.03	0.00	NR
11/1/2005	0.00	-0.04	0.00	-0.13	-0.06	-0.18	-0.05	-0.13	-0.19	-0.01	-0.06	0.05	-0.02	-0.01	0.00	NR
10/31/2006	0.00	-0.05	0.00	-0.14	-0.05	-0.19	-0.06	-0.13	-0.20	-0.01	-0.05	0.06	-0.02	-0.03	0.00	NR
11/7/2007	0.00	-0.05	0.00	-0.14	-0.07	-0.24	-0.05	-0.12	-0.21	-0.01	-0.06	0.06	-0.01	-0.01	0.00	NR
10/9/2008	0.00	-0.05	-0.01	-0.14	-0.08	-0.19	-0.06	-0.14	-0.18	-0.01	-0.05	0.06	-0.01	-0.02	0.00	NR
9/8/2009	0.00	-0.05	0.00	-0.14	-0.07	-0.18	-0.05	-0.12	-0.18	0.00	-0.04	0.08	0.00	-0.03	0.00	NR
change in disp.	0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.02	0.02	0.02	0.01	0.00	0.00	NR
10/08 to 9/09		Average change since last survey		=			0.01	or 0.12"								

Notes:

1) Negative transverse displacement signifies downstream movement

2) Positive transverse displacement signifies upstream movement

3) Displacement is net displacement since 1988

4) NR = monument not surveyed (Mon. 31 destroyed during new boat ramp construction; Mon. 30 new control pt)

5) Local Transverse data shown back calculated to 1988 - see text

6) Mons #16 and 30 are control points and do not show local transverse displacement

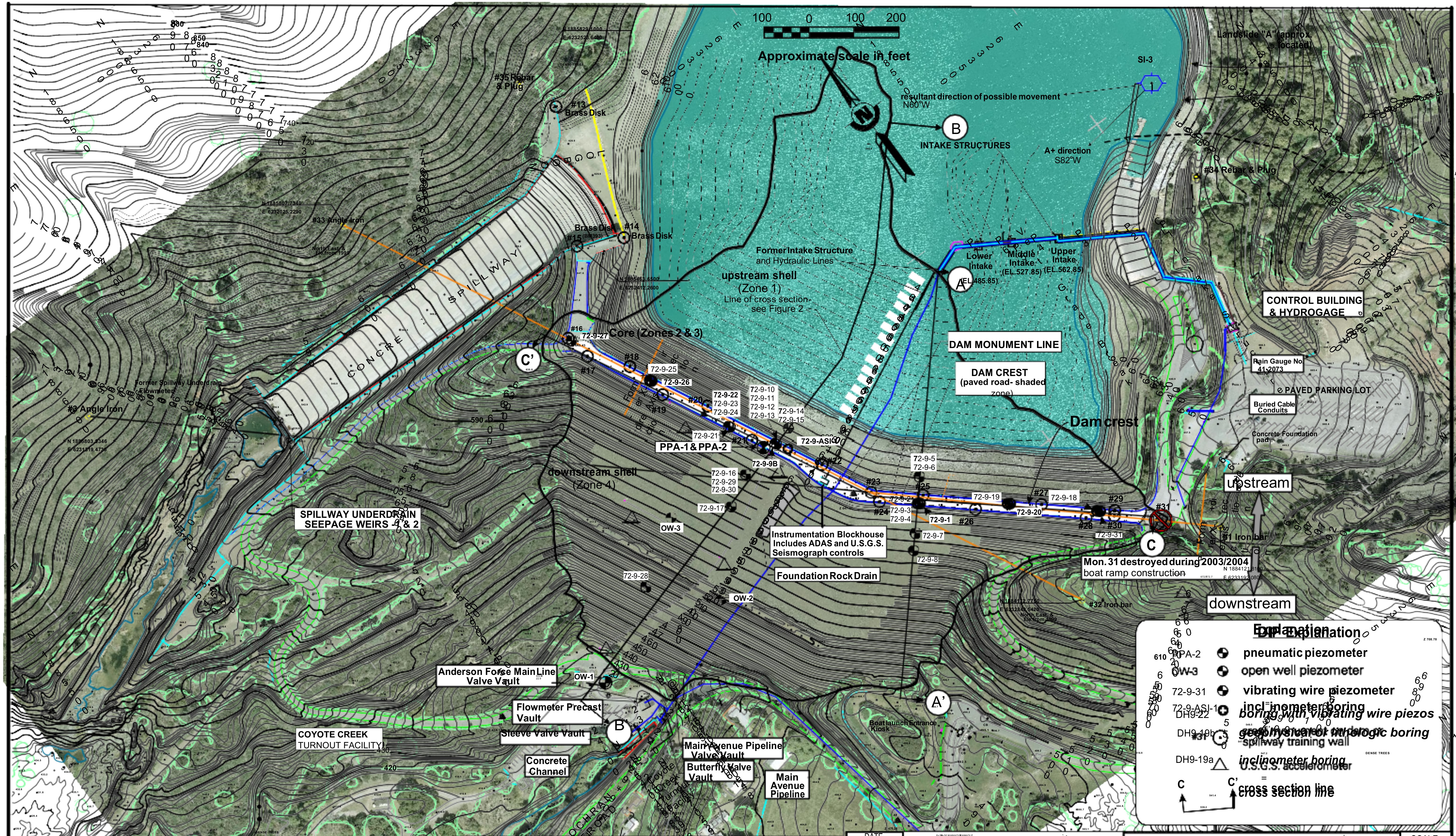
TABLE 6
Vertical Displacement Data
Spillway Training Wall Monuments
Leroy Anderson Dam

Date	Monument Vertical Displacement (feet)		
	13	14	15
12/11/1998	0.01	0.00	0.00
12/3/1999	0.01	-0.01	0.00
11/28/2000	0.01	-0.01	0.00
10/18/2001	0.03	-0.01	0.00
10/15/2002	NR	-0.01	0.00
11/4/2003	NR	-0.01	0.00
10/15/2004	NR	0.03	0.04
10/15/2004	NR	0.03	0.04
11/1/2005	NR	0.05	0.04
10/31/2006	NR	0.05	0.06
11/7/2007	NR	0.05	0.05
10/9/2008	NR	0.04	0.05
9/8/2009	NR	0.05	0.07
change in disp. 10/08 to 9/09	NR	0.01	0.03

Average change since last survey 0.02 or 0.24"

Notes:

1) Negative vertical displacement represents settlement
2) Positive vertical displacement represents heave


100 0 100 200
Approximate scale in feet
resultant direction of possible movement N60°W
B
INTAKE STRUCTURES
A+ direction S82°W
Landslide "A" (approx. located)
SI-3
#34 Rebar & Plug
#35 Rebar & Plug
#13 Brass Disk
#14 Brass Disk
#15 Brass Disk
#33 Angle iron
#3 Angle Iron
SPILLWAY
CONCRETE
Former Spillway Underdrain Flowmeter
Former Intake Structure and Hydraulic Lines
upstream shell (Zone 1)
Line of cross section-see Figure 2
Lower Intake (EL.485.85)
Middle Intake (EL.527.85)
Upper Intake (EL.562.85)
A
CONTROL BUILDING & HYDROGAGE
DAM MONUMENT LINE
DAM CREST (paved road- shaded zone)
Dam crest
Rain Gauge No 41-2073
PAVED PARKING LOT
Buried Cable Conduits
Concrete Foundation pad
upstream
downstream
Core (Zones 2 & 3)
C'
#16 #17 #18 #19 #20 #21 #22 #23 #24 #25 #26 #27 #28 #29 #30 #31
72-9-27 72-9-25 72-9-26 72-9-22 72-9-23 72-9-24 72-9-10 72-9-11 72-9-12 72-9-13 72-9-14 72-9-15 72-9-21 72-9-ASI 72-9-9B 72-9-16 72-9-29 72-9-30 72-9-17 72-9-5 72-9-6 72-9-2 72-9-3 72-9-4 72-9-1 72-9-7 72-9-8 72-9-19 72-9-20 72-9-18 72-9-31 72-9-28
PPA-1 & PPA-2
downstream shell (Zone 4)
OW-3 OW-2 OW-1
SPILLWAY UNDERDRAIN SEEPAGE WEIRS 1 & 2
Instrumentation Blockhouse Includes ADAS and U.S.G.S. Seismograph controls
Foundation Rock Drain
#1 Iron bar
C
Mon. 31 destroyed during 2003/2004 boat ramp construction
#32 Iron bar
Anderson Force Main Line Valve Vault
Flowmeter Precast Vault
Sleeve Valve Vault
B
COYOTE CREEK TURNOUT FACILITY
Concrete Channel
Main Avenue Pipeline Valve Vault
Butterfly Valve Vault
Main Avenue Pipeline
A'
Boat launch Entrance Kiosk
COCHRAN ROAD
Explanation
DIP Explanation
PPA-2 pneumatic piezometer
OW-3 open well piezometer
72-9-31 vibrating wire piezometer
72-9-ASI-1 inclinometer boring
DH9-22 boring with vibrating wire piezos
#31 crest monument on dam or spillway training wall
DH9-19b geophysical or lithologic boring
U.S.G.S. accelerometer
DH9-19a inclinometer boring
C C' cross section line

Reference information and notes:

1) This map is a compilation of aerial mapping, survey field data, and digitized construction maps. Maximum error could be **± one foot vertical and horizontal; error greater for upstream topographic lines (see note 7)**
2) Grid is based on California Coordinate System, Zone III, NAD 83.
3) Elevations based on N.G.S. Vertical datum, NAVD 88. The DE between NAVD 29 and NGVD 88 is 2.80'
4) Photogrammetric mapping: Transvision, Photo date 12/11/97; color photo date April 2001
5) file W:\geology\DAMS\Historic Dam Geology\anderson\ANDHistgeo.cdr
6) selected 1987-88 dam raise values in feet shown in red
7) upstream dam topography (dashed lines) from as-built 1988 "Leroy Anderson Dam Intake Structure Modification, Sheet 2, scale 1"=100', dated 1-8-88, from 10-7-87 aerial photography, modified to NGVD 88

DATE	01/20/09
DESIGN	JLN
DRAWN	JLN
CHECKED	RLV

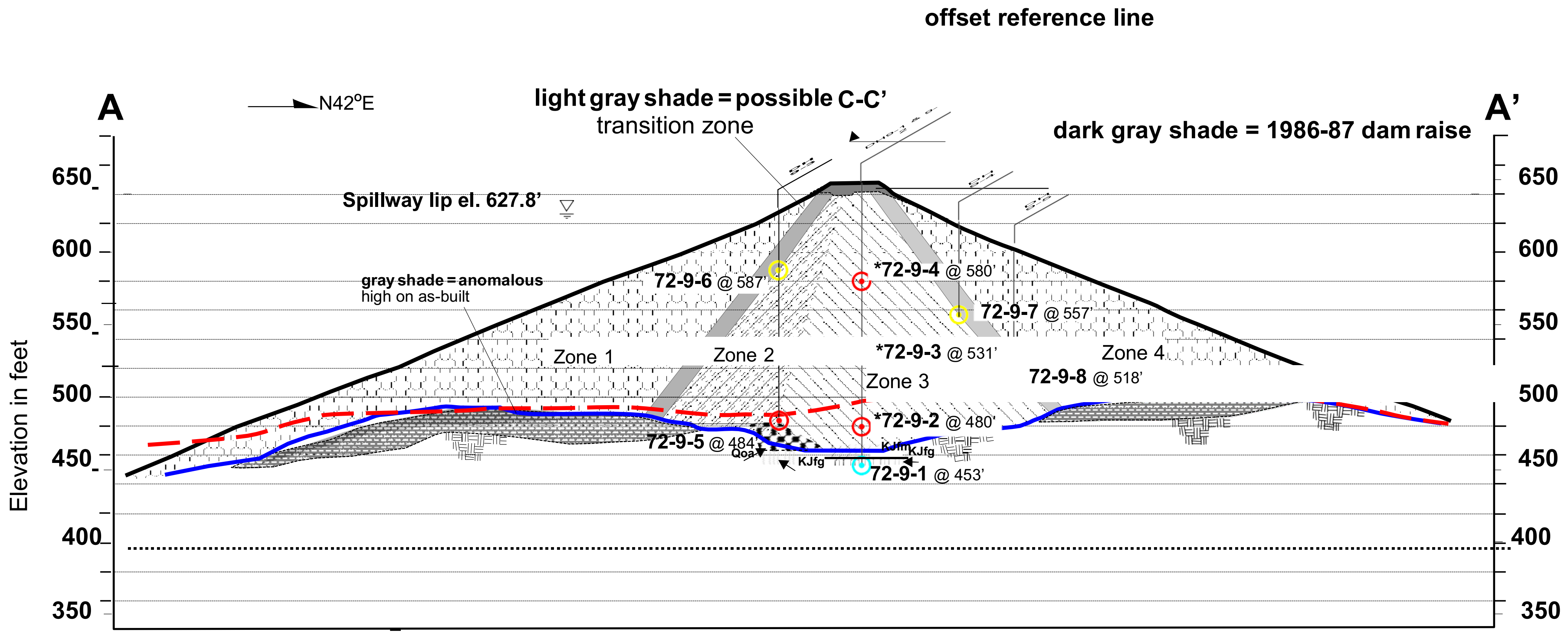
Santa Clara Valley Water District

Topographic Map
Surveillance Instrumentation
Leroy Anderson Dam

SCALE
1" = 200'

PLATE
1

Section A-A' (sta. 6+00)



Explanation

boring number

72-9-8 ⊙ **vibrating wire** piezometer

excavated topography (as-built) adjusted **to DIP drill hole logs**

excavated topography (as-built) adjusted **2.8' for new datum**

original topography adjusted **2.8' for new datum**

***= installed using grout-in methods (see text)**
all other piezometers installed using sand-pack methods

Bedrock & Soil Foundation Units from DIP/SSE1B

▩ **Qoa/Qc = Quaternary older alluvium and/or** colluvium

▤ **QTsc = Plio-Pleistocene Santa Clara Fm**

▨ **KJfm = Franciscan Complex melange**

▥ **KJfg = Franciscan Complex greenstone**

⊙ **red = embankment**
⊙ yellow = transition zone
⊙ green = colluvium/alluvium
⊙ blue = foundation

Notes:
1) File: W:\geology\dams\Historic_Dam_Geology\Anderson\andxsecA-A'rev.cdr
2) basis of elevations is NAVD 1988-elevations are 2.80' higher than NGVD 1929

DATE 11/04/09
DESIGN JLN
DRAWN JLN
CHECKED DEH

Santa Clara Valley Water District

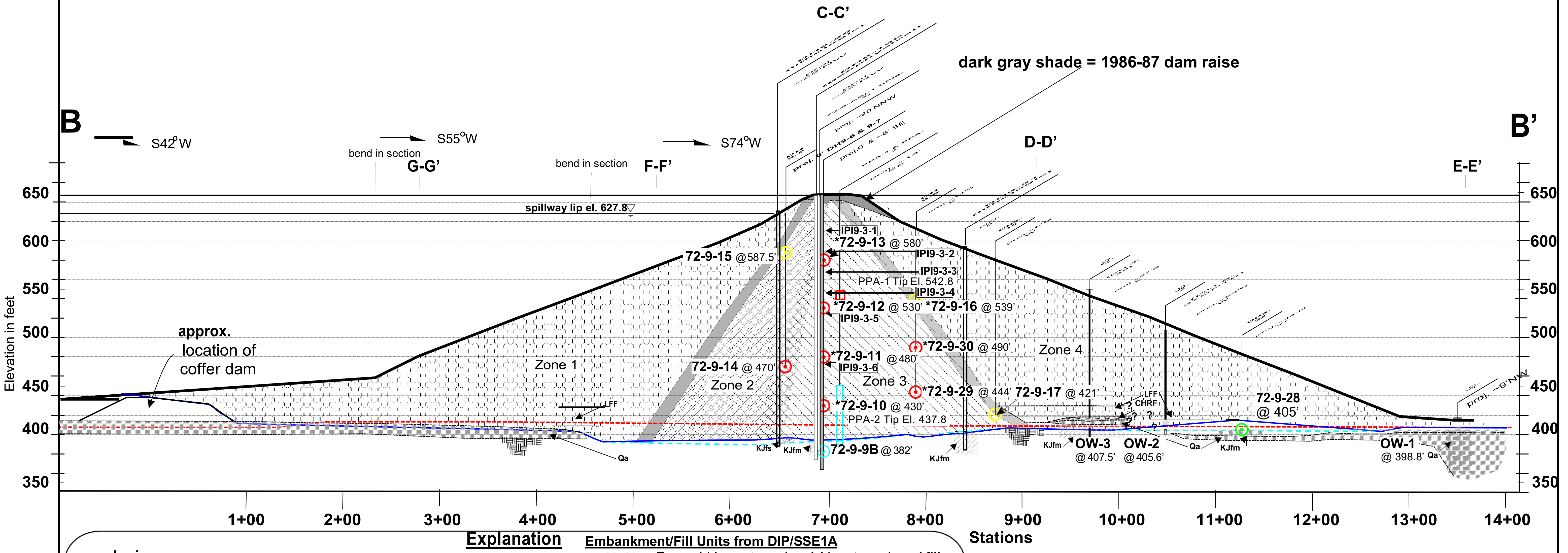
Cross Section A-A'

Leroy Anderson Dam

SCALE 1"=100'

PLATE 2

Section B-B' (transverse max section along thalweg)



Explanation

boring number

72-9-28 ⊙ vibrating wire piezometer

72-9-ASI-2 automated slope indicator

DH9-20 geophysical

DH9-20 lithologic logging

excavated topography (as-built) corrected 2.8' for new datum

excavated topography (as-built) adjusted to DIP drill hole logs

original topography corrected 2.8' for new datum

* = installed using grout-in methods (see text)
all other piezometers installed using sand-pack methods

Embankment/Fill Units from DIP/SSE1A

Zones 1 (downstream) and 4 (upstream): rockfill
Transition Zones, downstream and upstream
Zone 2 upstream core
Zone 3 downstream core
Construction haul road fill (CHRF)
Lower Finer Fill (LLF), downstream and upstream

Bedrock and Foundation Soil Units from DIP/SSE1A

Qa/Qc = Quaternary alluvium and/or colluvium
KJfm = Franciscan Complex melange
⊙ red = embankment
⊙ yellow = transition zone
⊙ green = colluvium/alluvium
⊙ blue = foundation

Notes:
1) File: W:\geology\dams\historic dam geology\anderson\andxsecB-B'rev.cdr
2) basis of elevations is NAVD 1988-elevations are 2.80' higher than NGVD 1929

DATE	12/18/08
DESIGN	RLV
DRAWN	JLN
CHECKED	RLV

Santa Clara Valley Water District

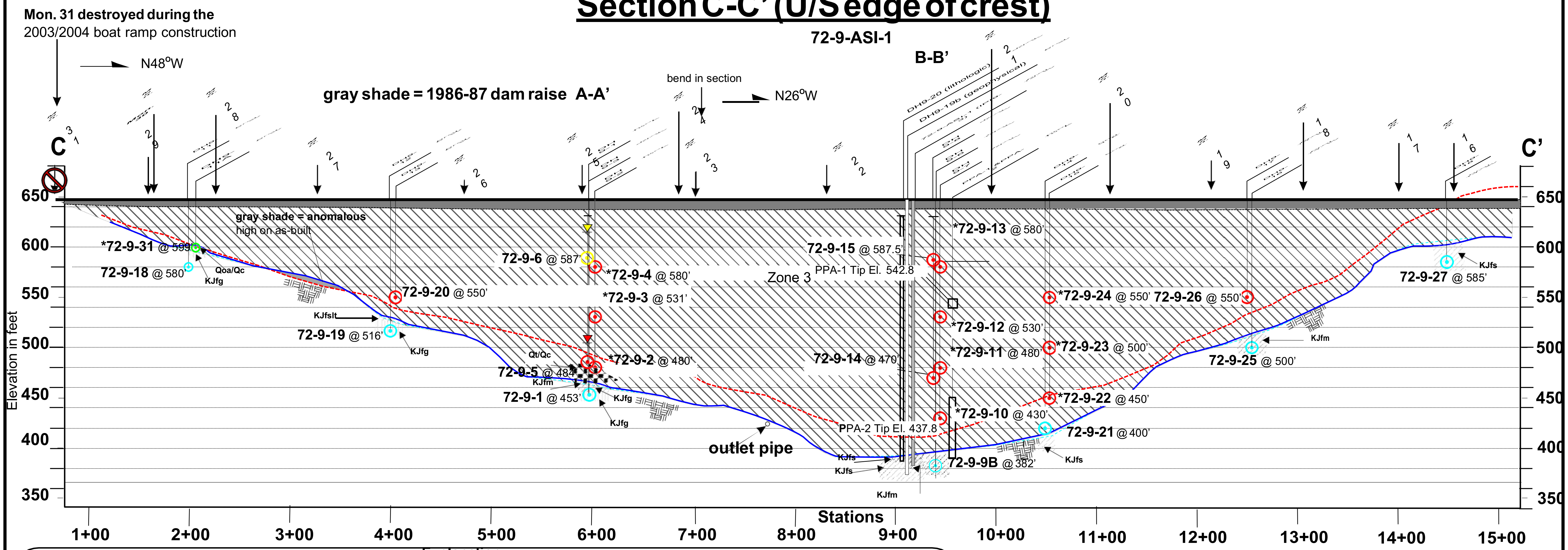
Cross Section B-B'

Leroy Anderson Dam

SCALE
1"=100'

PLATE
3

Section C-C' (U/S edge of crest)



Explanation

boring number

72-9-ASI-2

automated slope indicator

geophysical/ lithologic logging

vibrating wire piezometer

72-9-27 ⊙

excavated topography (as-built) corrected 2.8' for new datum

excavated topography (as-built) adjusted to DIP drill hole logs

original topography corrected 2.8' for new datum

* = installed using grout-in methods (see text)
all other piezometers installed using sand-pack methods

Bedrock and Foundation Soil Units from DIP

- ▦ Qoa/Qc = Quaternary older alluvium and/or colluvium
- ▨ KJfm = Franciscan Complex melange
- ▥ KJfg = Franciscan Complex greenstone
- ▨ KJfs = Franciscan Complex sandstone

- ⊙ red = embankment
- ⊙ green = colluvium/alluvium
- ⊙ blue = foundation

Notes:
1) File: W:\Geology\DAMS\Historic_Dam_Geology\Anderson\andxsecC-CDIP.cdr
2) basis of elevations is NAVD 1988-elevations are 2.80' higher than NGVD 1929

DATE
12/18/08
DESIGN
RLV
DRAWN
JLN
CHECKED
RLV

Santa Clara Valley Water District

Longitudinal Cross Section C-C'

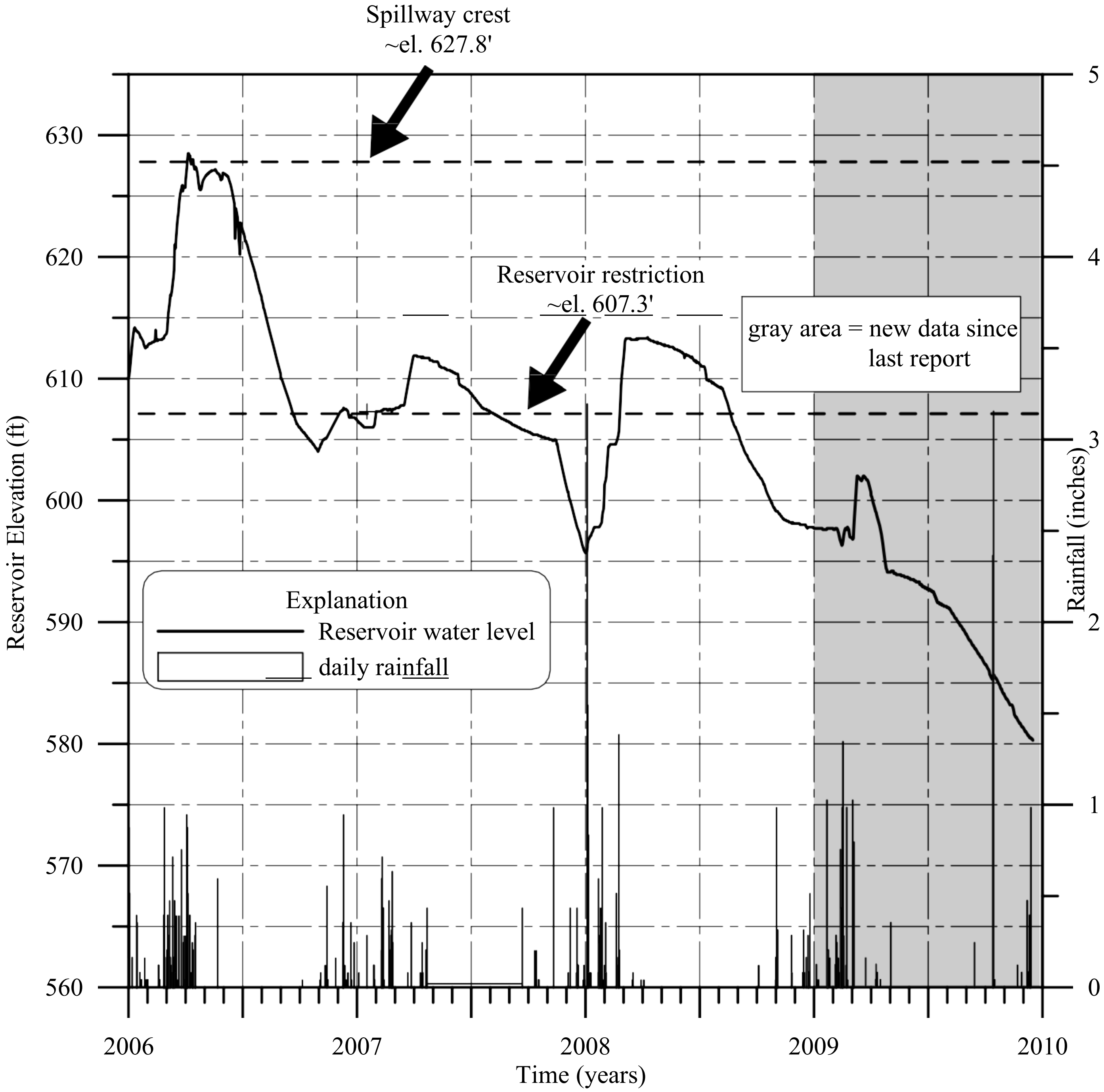
Leroy Anderson Dam

SCALE
1"=100'

PLATE
4

LEROY ANDERSON DAM

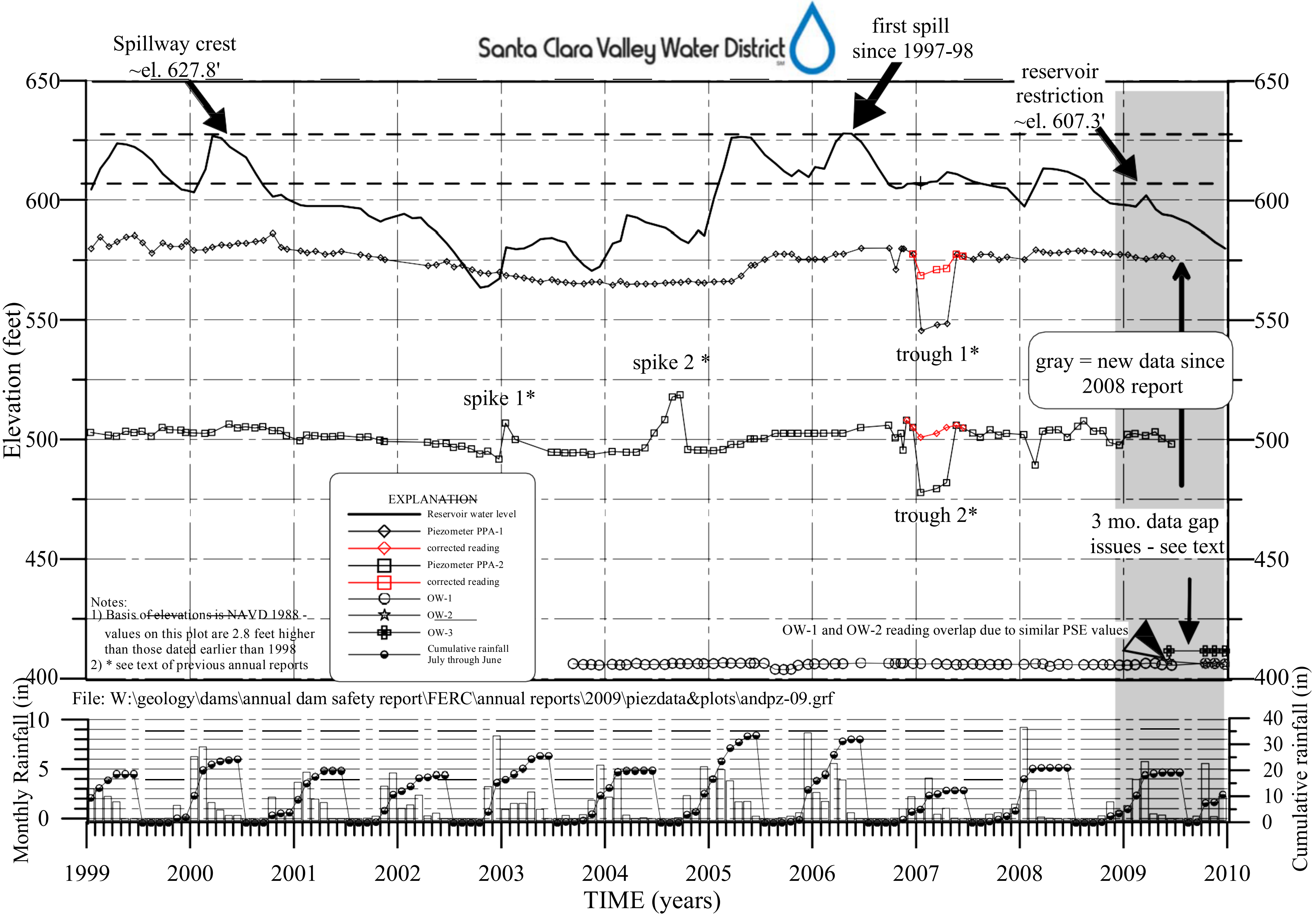
Santa Clara Valley Water District



Notes: 1) basis of elevations is NAVD 1988 - values are 2.8 feet higher than NGVD 1929
2) file W:\geology\dams\annual dam safety reports\FERC\Annual Reports\2009\Andresplot-09

Figure 5. Daily Reservoir Elevation and Rainfall 2006-2010

LEROY ANDERSON DAM



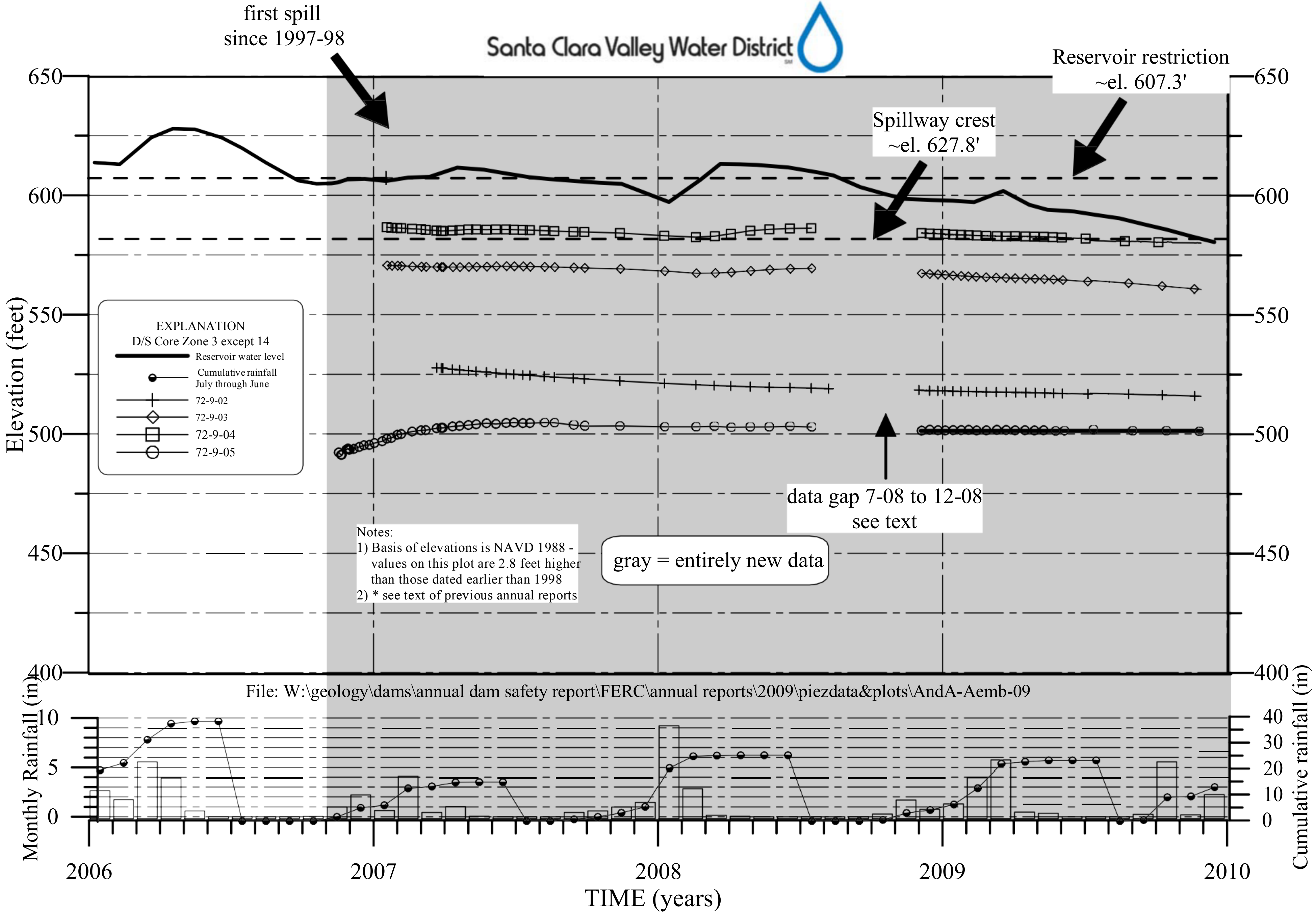
Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than those dated earlier than 1998
2) * see text of previous annual reports

File: W:\geology\dams\annual dam safety report\FERC\annual reports\2009\piezdata&plots\andpz-09.grf

Figure 6. Pneumatic and Open Well Piezometer Levels - Embankment & Foundation

LEROY ANDERSON DAM

Santa Clara Valley Water District



first spill since 1997-98

Reservoir restriction ~el. 607.3'

Spillway crest ~el. 627.8'

data gap 7-08 to 12-08 see text

gray = entirely new data

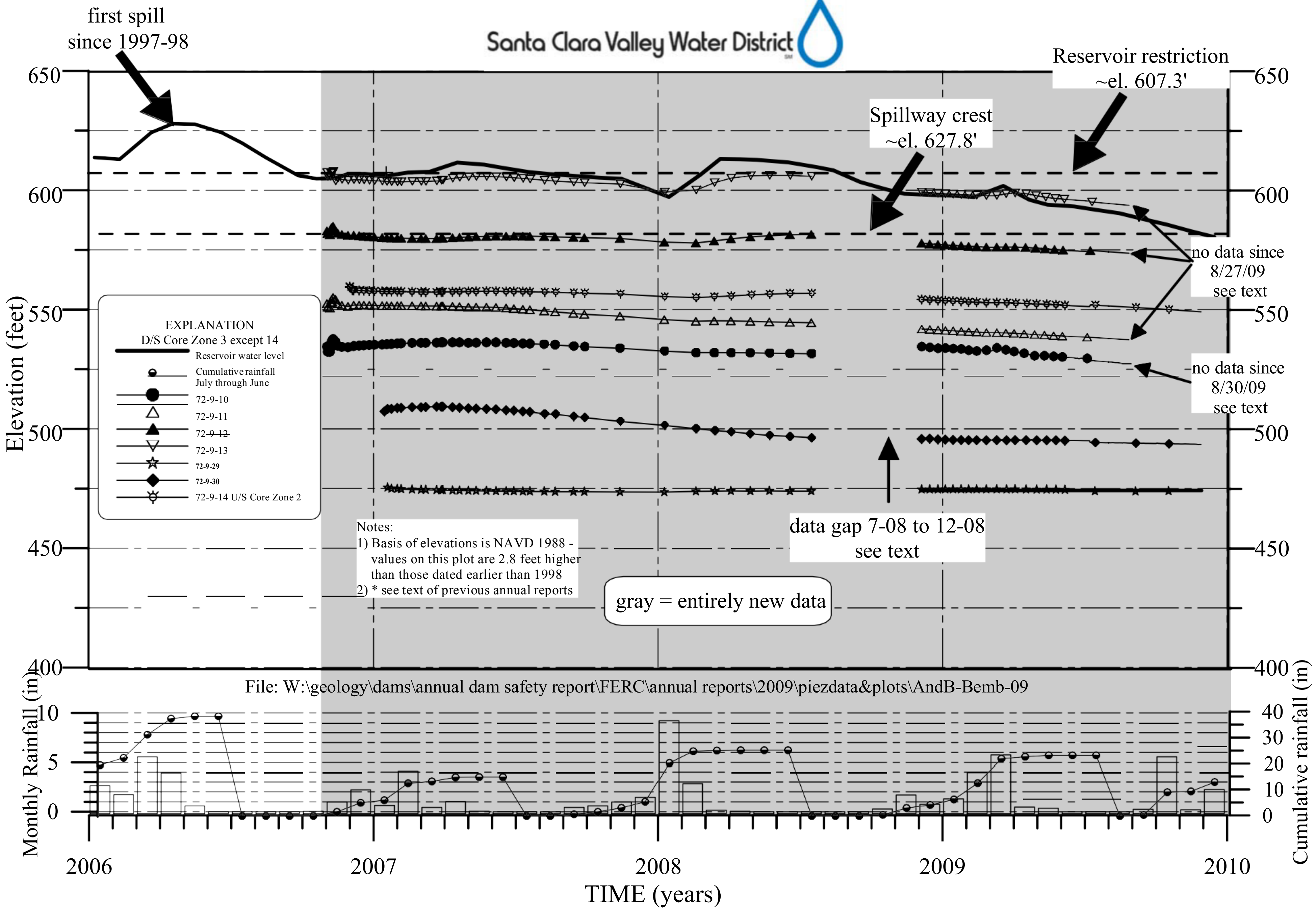
Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than those dated earlier than 1998
2) * see text of previous annual reports

File: W:\geology\dams\annual dam safety report\FERC\annual reports\2009\piezdata&plots\AndA-Aemb-09

Figure 7. Piezometer Levels Section A-A'- Embankment

LEROY ANDERSON DAM

Santa Clara Valley Water District



Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than those dated earlier than 1998
2) * see text of previous annual reports

File: W:\geology\dams\annual dam safety report\FERC\annual reports\2009\piezdata&plots\AndB-Bemb-09

Figure 8. Piezometer Levels Section B-B'- Embankment

LEROY ANDERSON DAM

Santa Clara Valley Water District

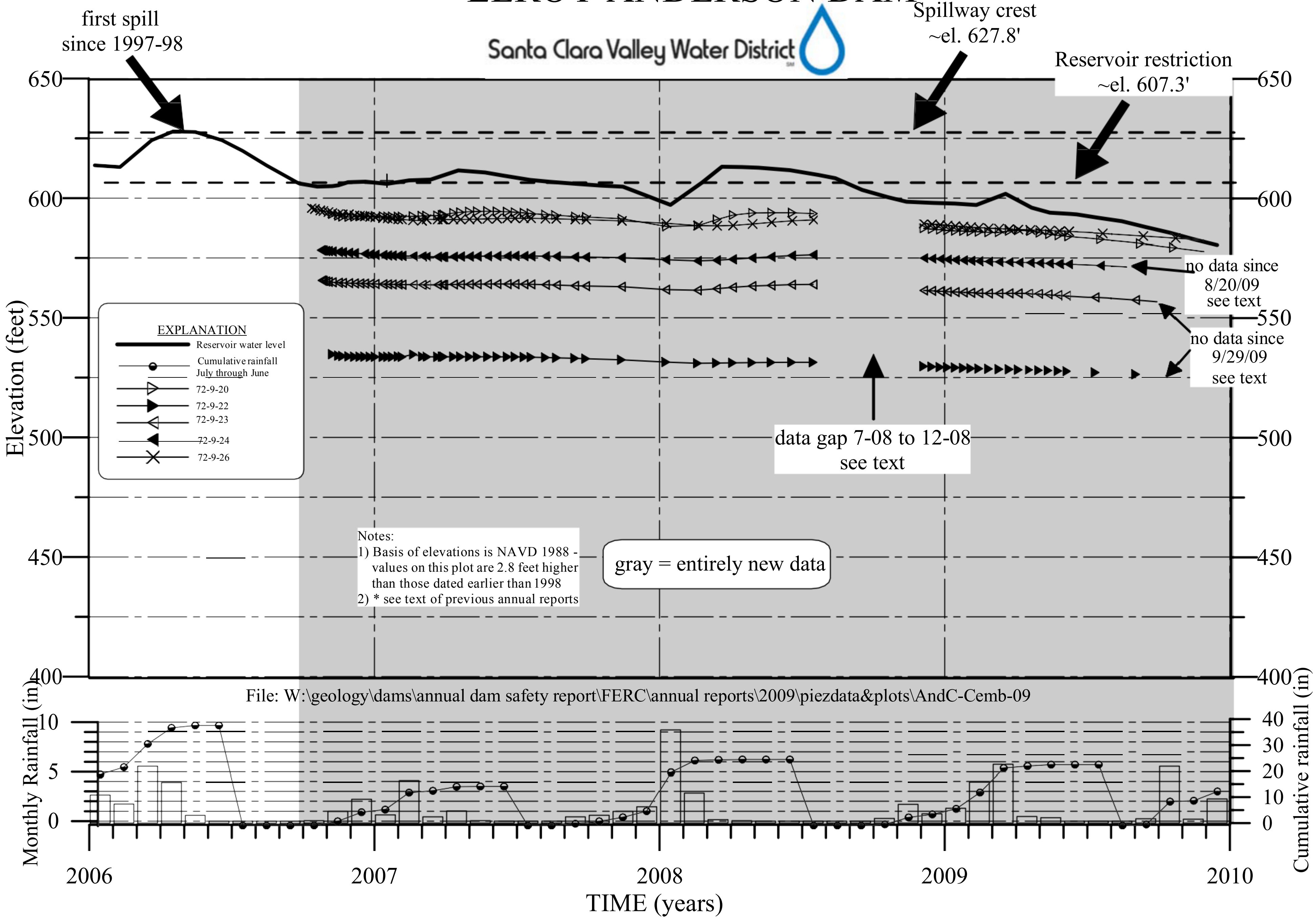
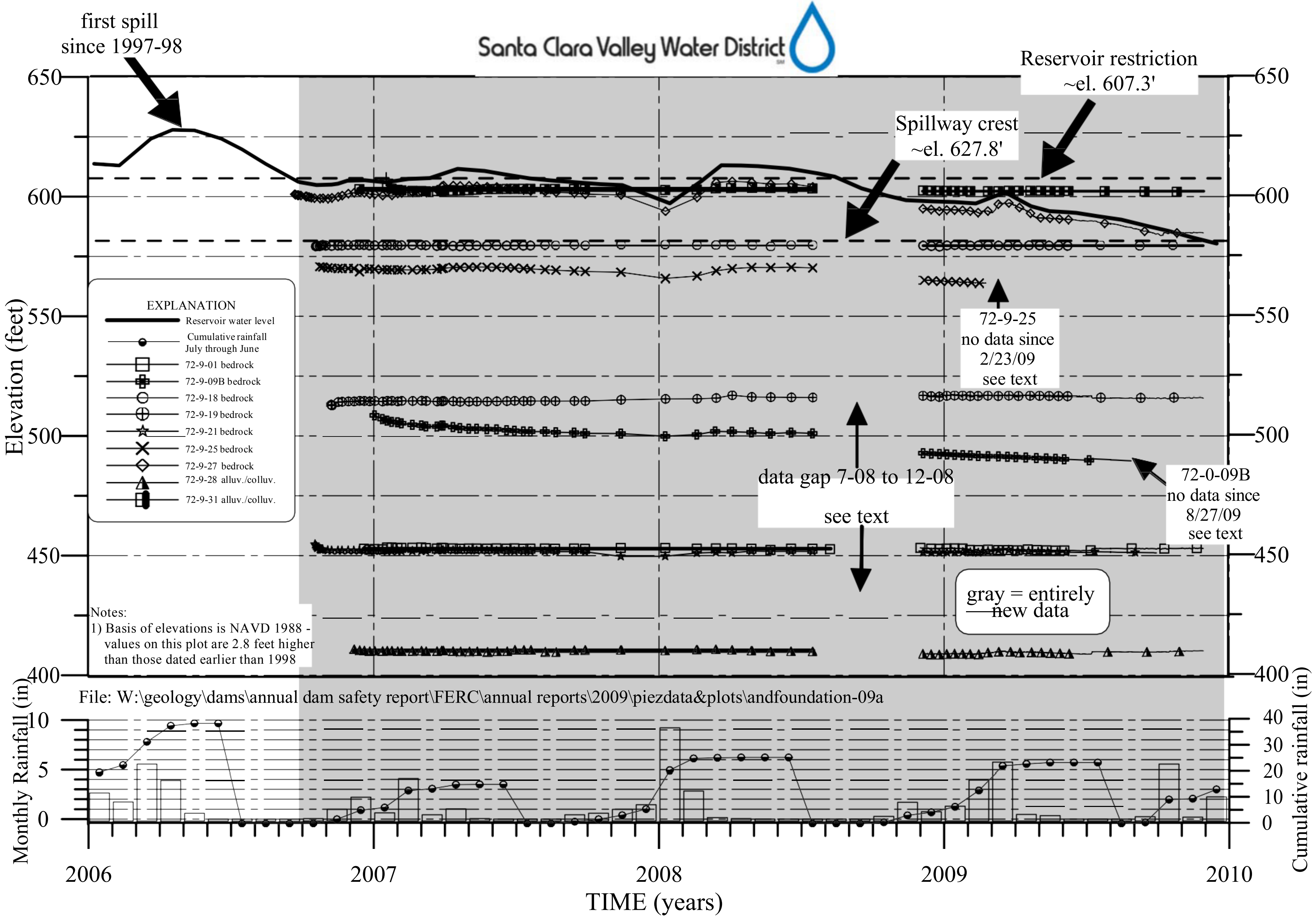


Figure 9. Piezometer Levels Section C-C' - Embankment

LEROY ANDERSON DAM



Notes:
1) Basis of elevations is NAVD 1988 - values on this plot are 2.8 feet higher than those dated earlier than 1998

File: W:\geology\dams\annual dam safety report\FERC\annual reports\2009\piezdata&plots\andfoundation-09a

Figure 10. Piezometer Levels - Foundation Bedrock and Alluvium/Colluvium

LEROY ANDERSON DAM

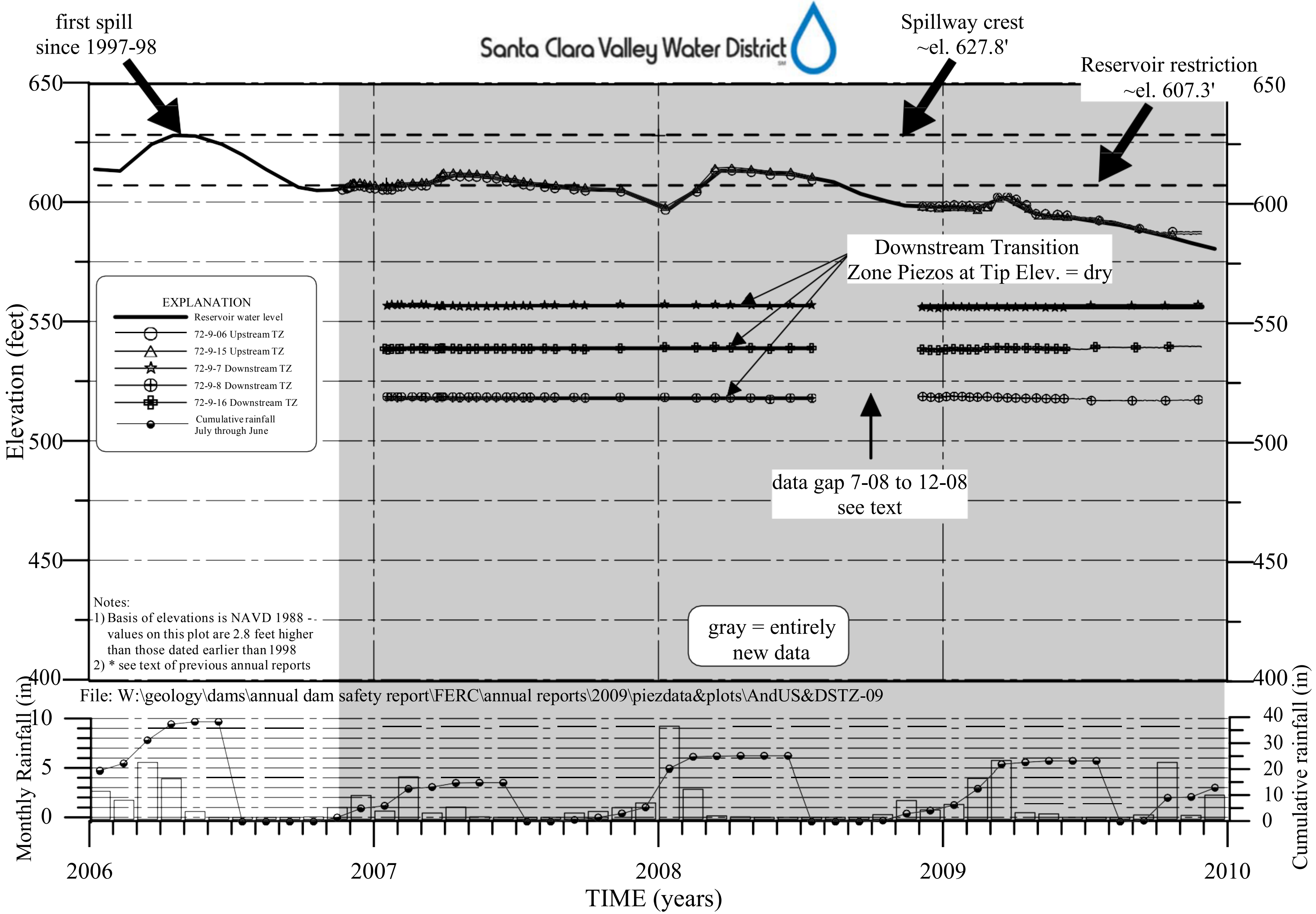
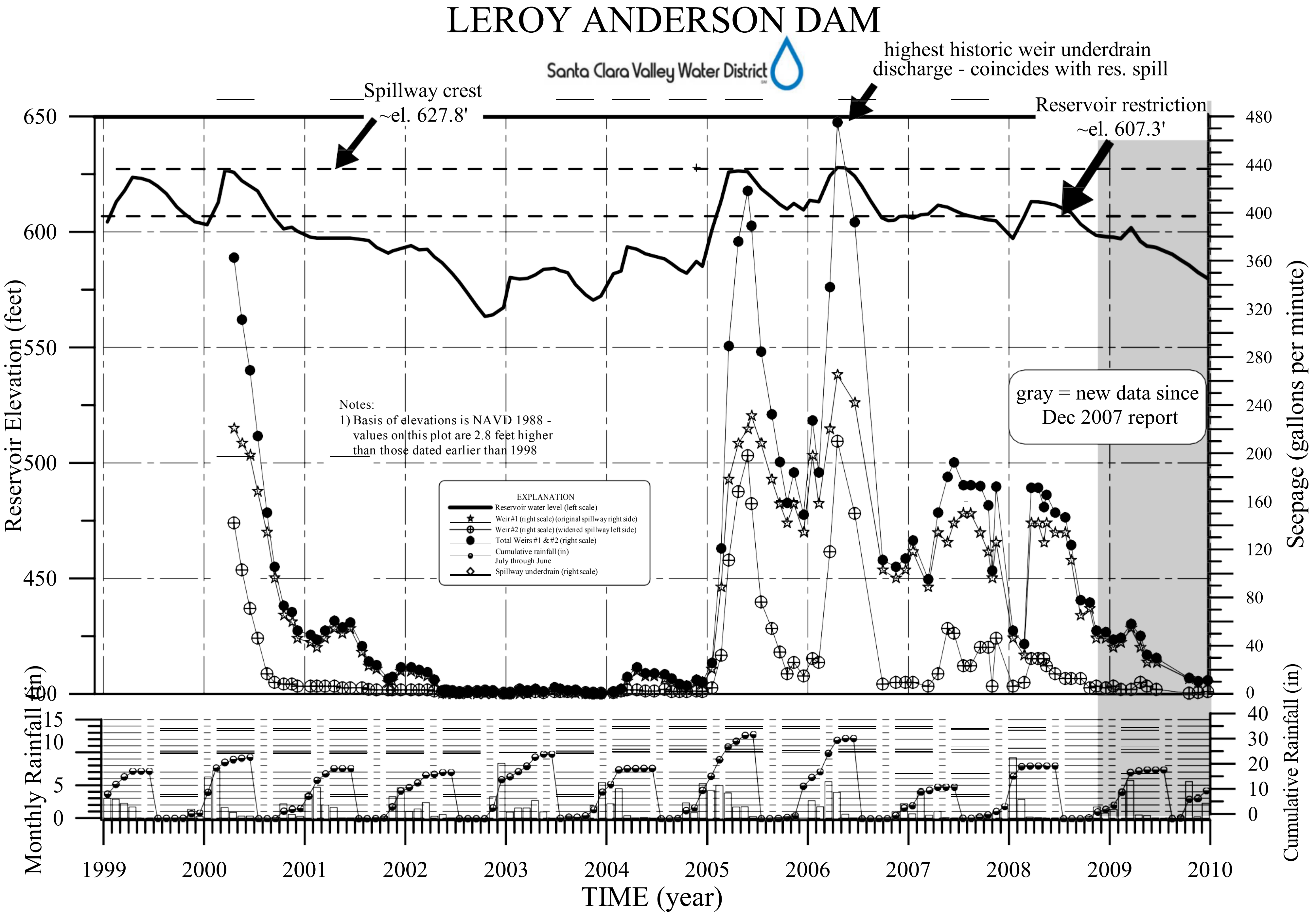


Figure 11. Piezometer Levels - Upstream & Downstream Transition Zones

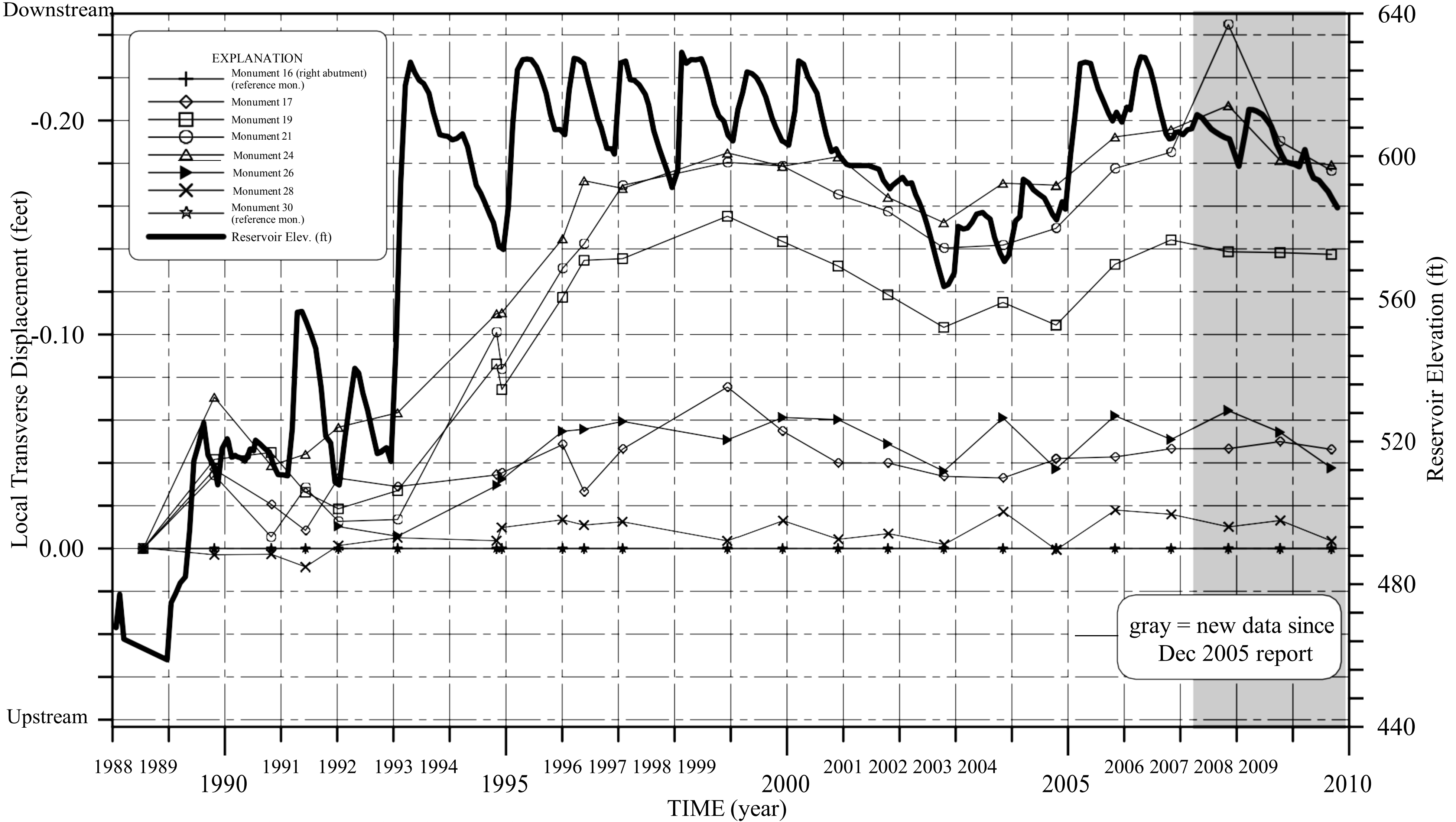


File: W:\geology\dams\annual dam safety report\FERC\annual reports\2009\weirdata&plots\andweir-09.grf

Figure 12. Weir Discharge Data - Spillway Underdrains

LEYROY ANDERSON DAM

Santa Clara Valley Water District



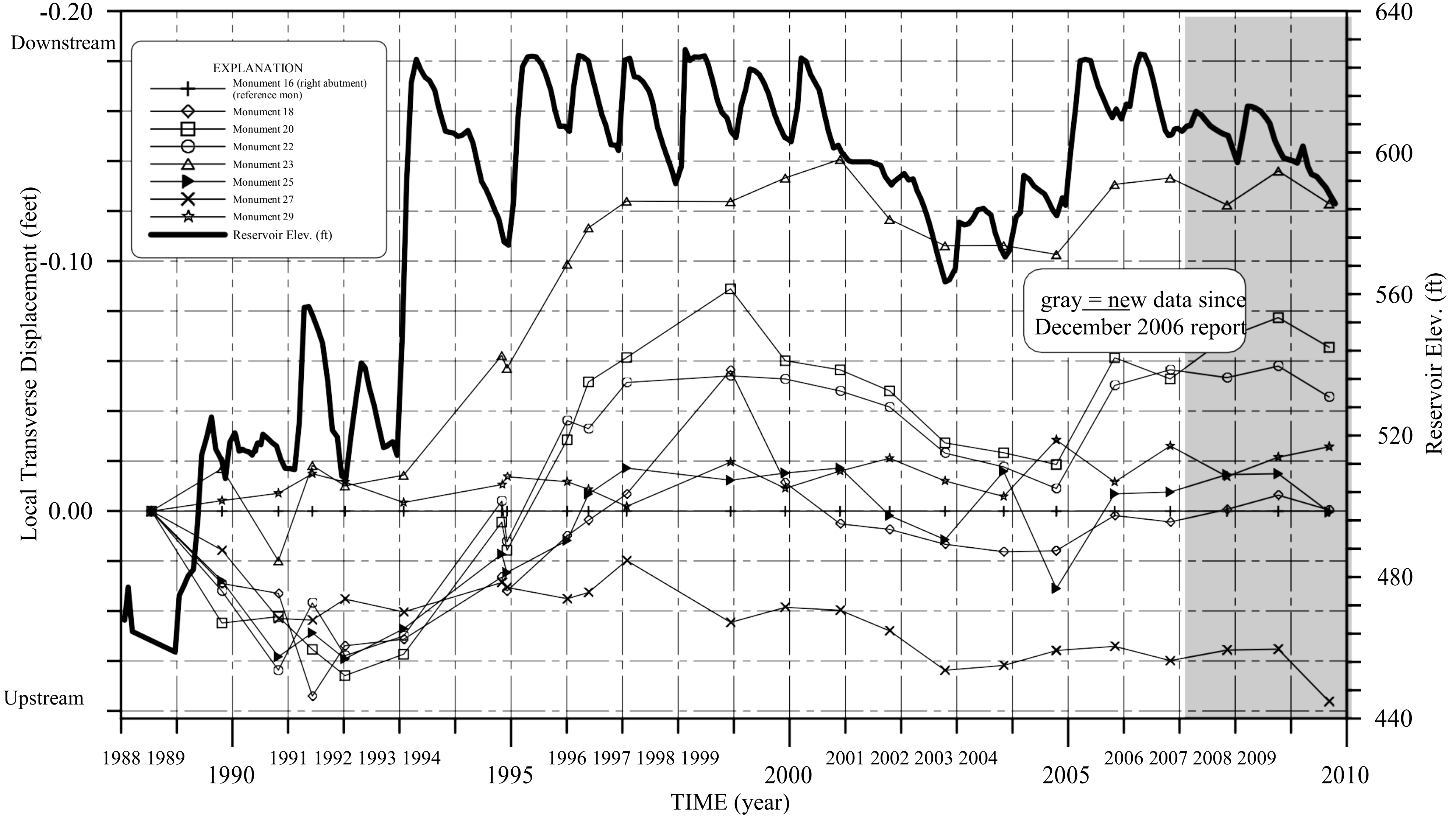
Note: 2004 survey data includes old and new epochs (two data points per monument)

File: W:\geology\annual dam safety reports\FERC\anderson\2009\piezdata&plots\andLa10y-09rev.grf

Figure 13 - Local Transverse Displacements - Monuments at Downstream Edge of Crest

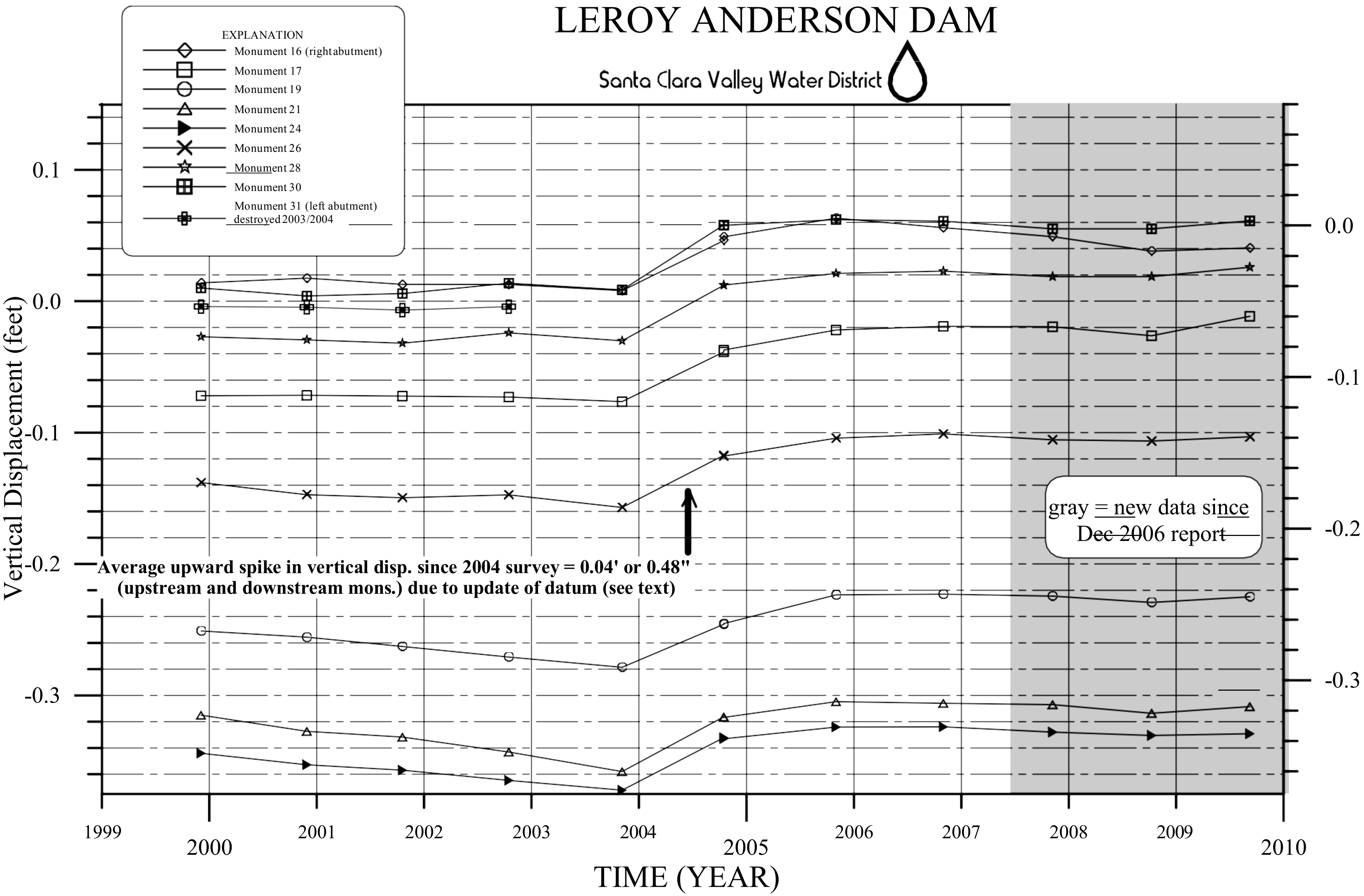
LEYROY ANDERSON DAM

Santa Clara Valley Water District



File: W:\geology\annual dam safety reports\FERC\anderson\2009\piezdata&plots\andl10y-09rev.grf

Figure 14 - Local Transverse Displacements - Monuments at Upstream Edge of Crest

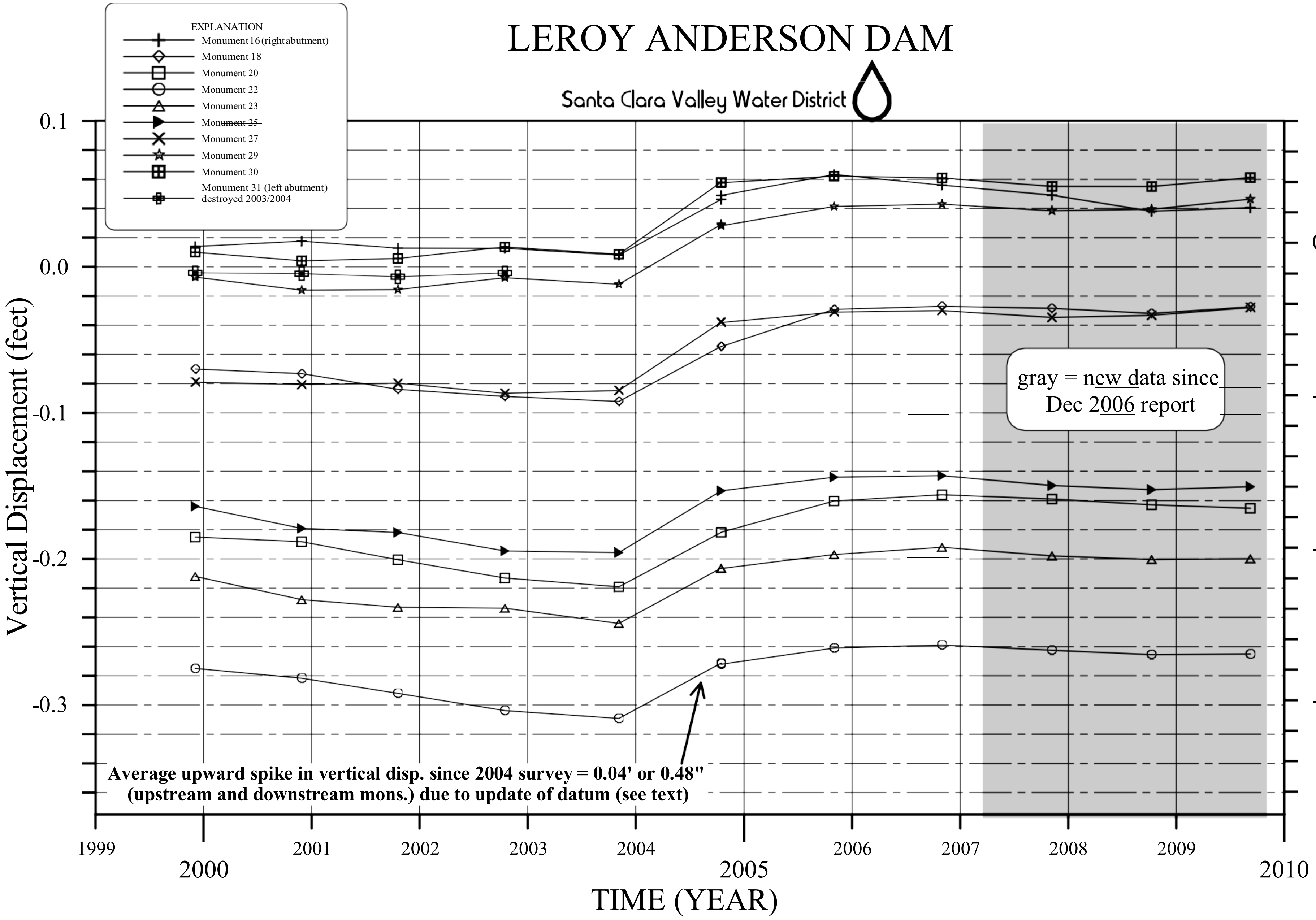


Average upward spike in vertical disp. since 2004 survey = 0.04' or 0.48"
(upstream and downstream mons.) due to update of datum (see text)

gray = new data since
Dec 2006 report

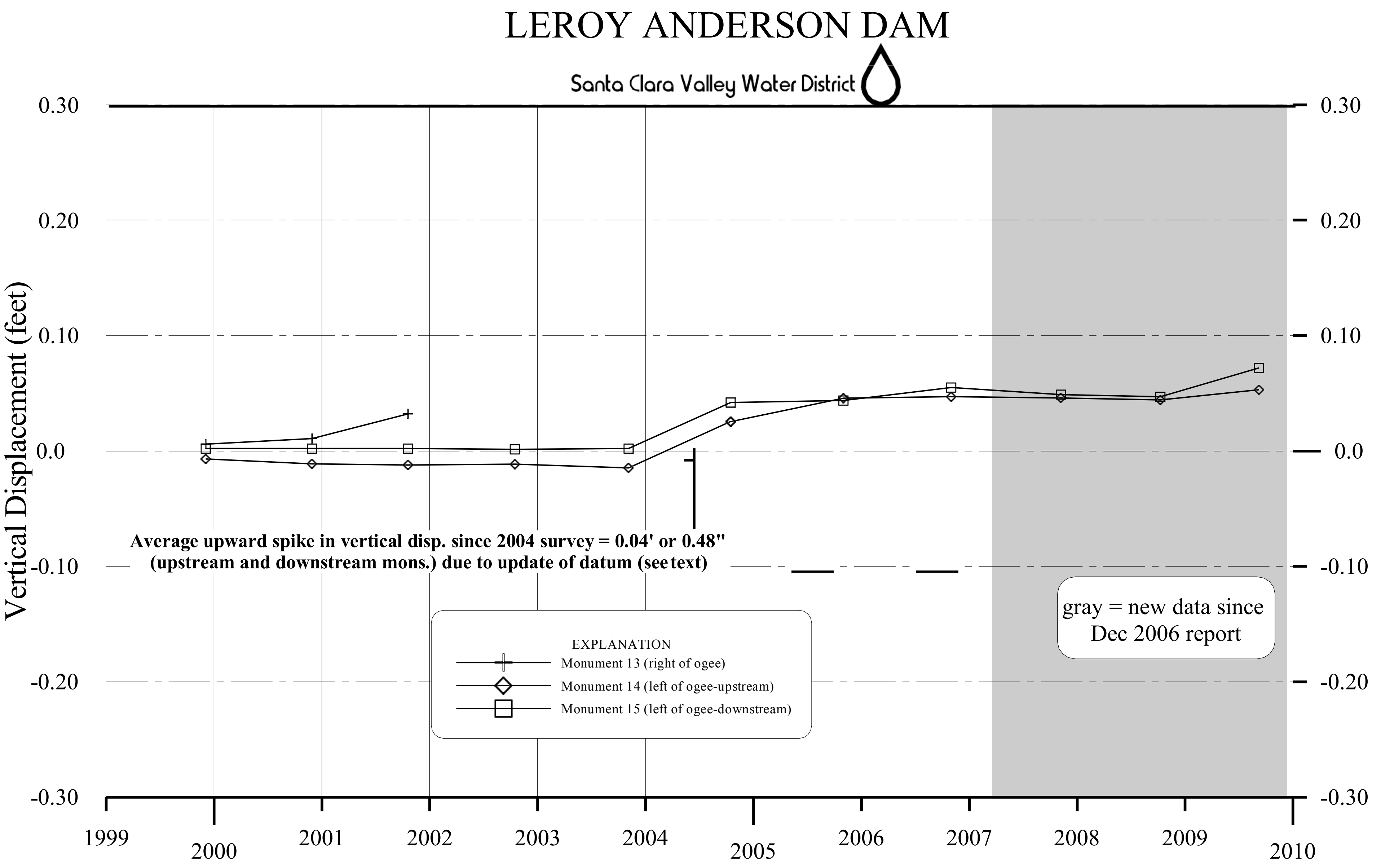
File W:\geology\annual dam safety reports\FERC\2009\survey\andvert1-09.grf

Figure 15 - Vertical Displacements - Monuments at Downstream Edge of Crest



File W:\geology\annual dam safety reports\FERC\2009\survey\andvert2-09.grf

Figure 16 - Vertical Displacements - Monuments at Upstream Edge of Crest



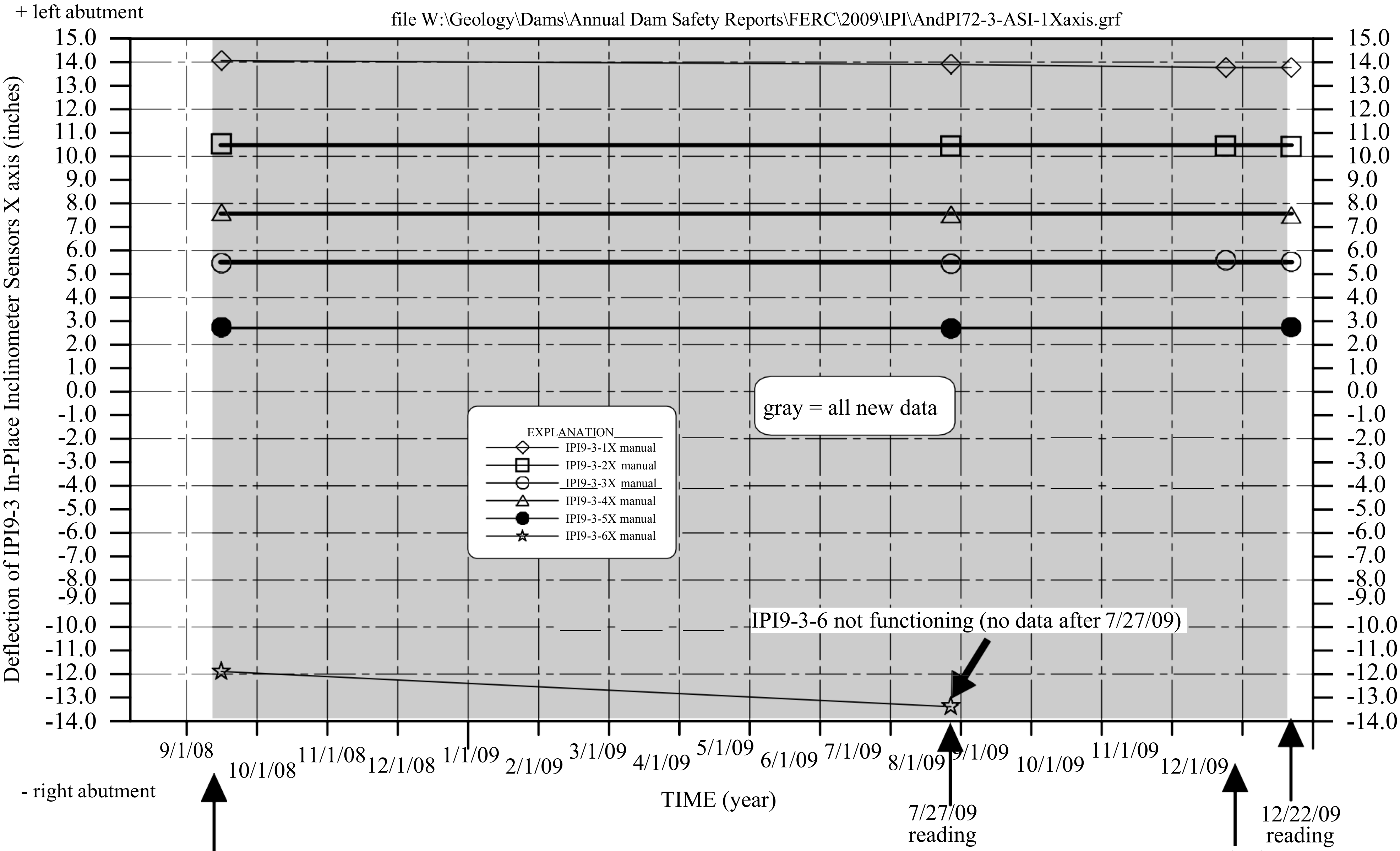
Note: Mon. 13 not surveyed since October 2001

File W:\geology\annual dam safety reports\FERC\2009\survey\andvert3-09.grf

Figure 17 - Vertical Displacements - Spillway Training Walls

LEROY ANDERSON DAM

Santa Clara Valley Water District



9/16/08 reading

11/24/09 reading

Figure 18. Deflection of Crest Inclinometer IPI9-3, X axis

LEROY ANDERSON DAM

Santa Clara Valley Water District

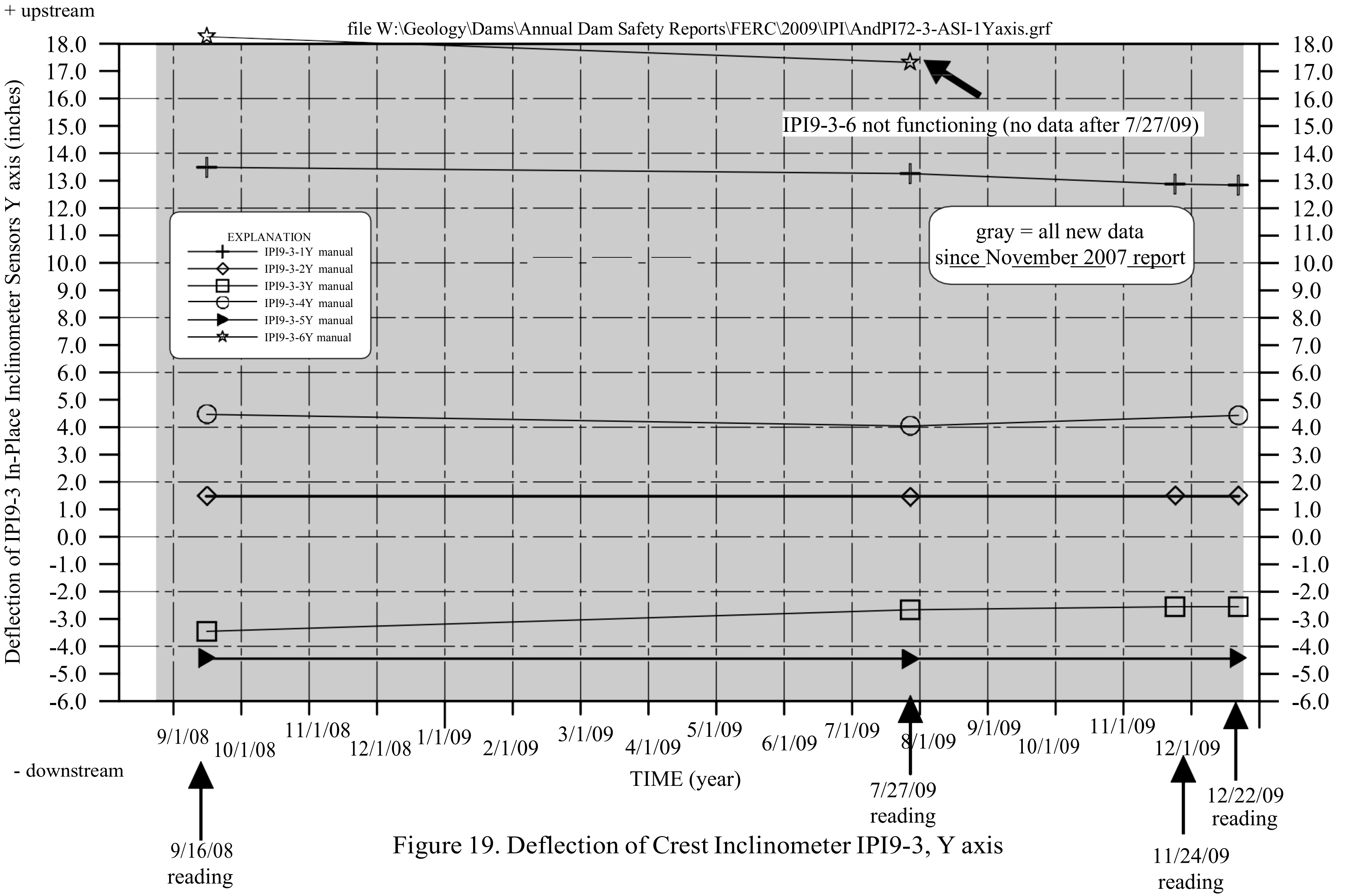
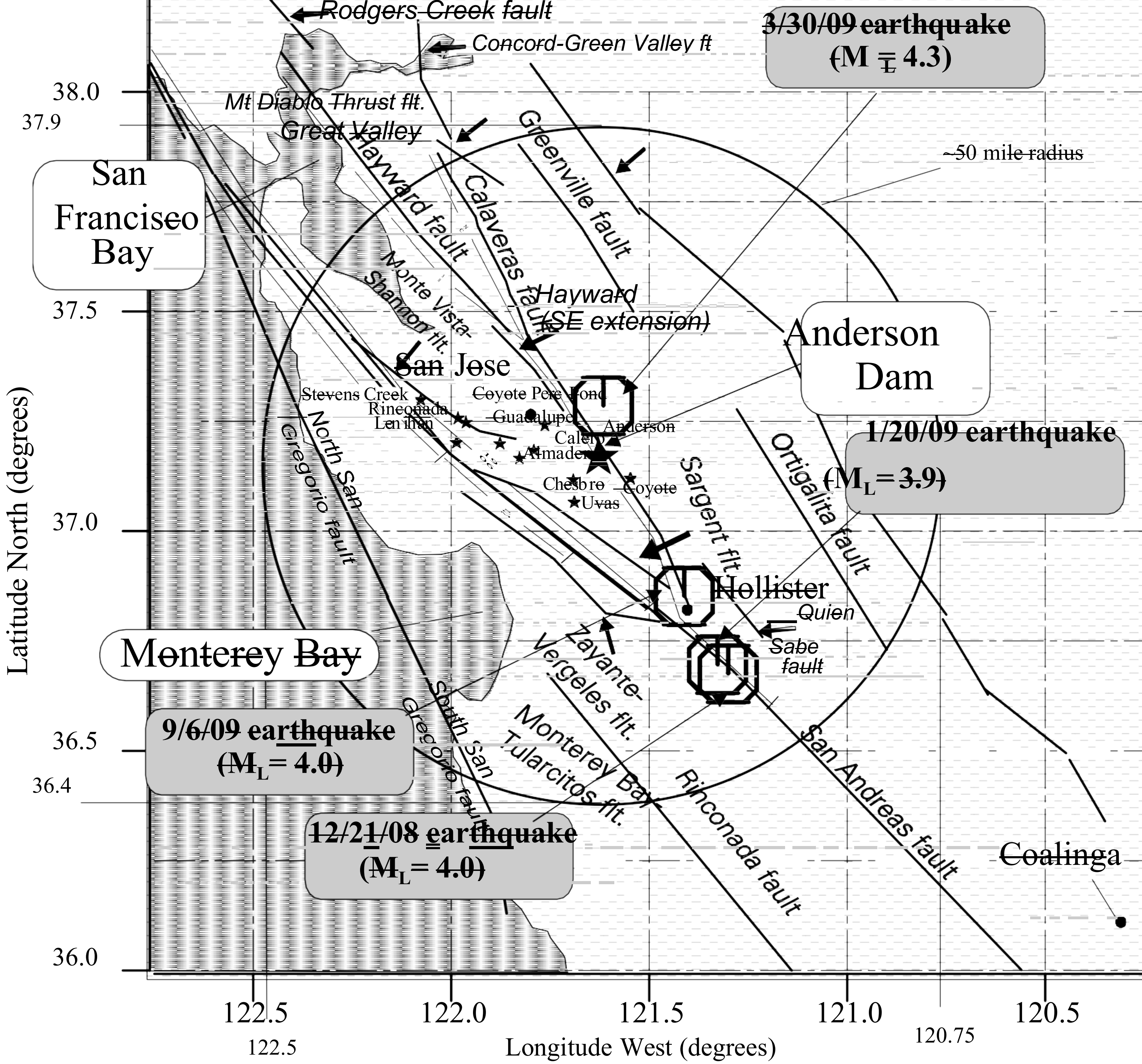


Figure 19. Deflection of Crest Inclinometer IPI9-3, Y axis

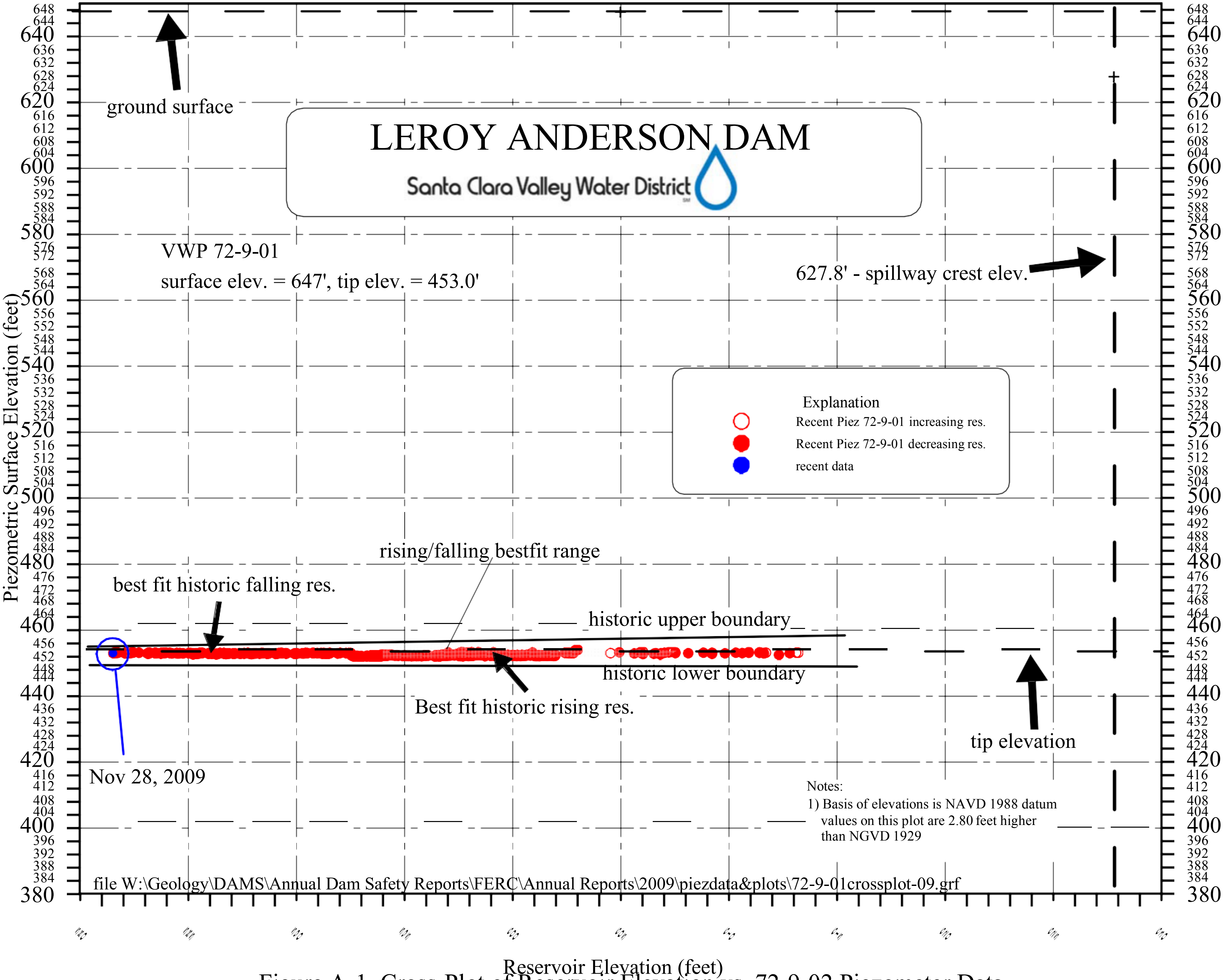

Rodgers Creek fault
Concord-Green Valley ft
3/30/09 earthquake
(M L = 4.3)
Mt Diablo Thrust flt.
Great Valley
~50 mile radius
San Francisco Bay
Hayward fault
Calaveras fault
Greenville fault
Monte Vista-Shannon flt.
Hayward (SE extension)
Anderson Dam
San Jose
Stevens Creek
Coyote Perc Pond
Rinconada
Guadalupe
Lenihan
Calero
Anderson
Almaden
Chesbro
Coyote
Uvas
1/20/09 earthquake
(M L = 3.9)
Sargent flt.
Ortigalita fault
North San Gregorio fault
Hollister
Quien Sabe fault
Monterey Bay
Zayante-Vergeles flt.
9/6/09 earthquake
(M L = 4.0)
South San Gregorio fault
Monterey Bay-Tularcitos flt.
Rinconada fault
San Andreas fault
12/21/08 earthquake
(M L = 4.0)
Coalinga
38.0
37.9
37.5
37.0
36.5
36.4
36.0
Latitude North (degrees)
122.5
122.0
121.5
121.0
120.5
122.5
120.75
Longitude West (degrees)

DATE
12/1/09

Appendix A – Piezometer & Weir Cross Plots

Figures A-1 through A-34 Cross Plots of Reservoir Elevations versus Piezometric Surface Elevations at Leroy Anderson Dam

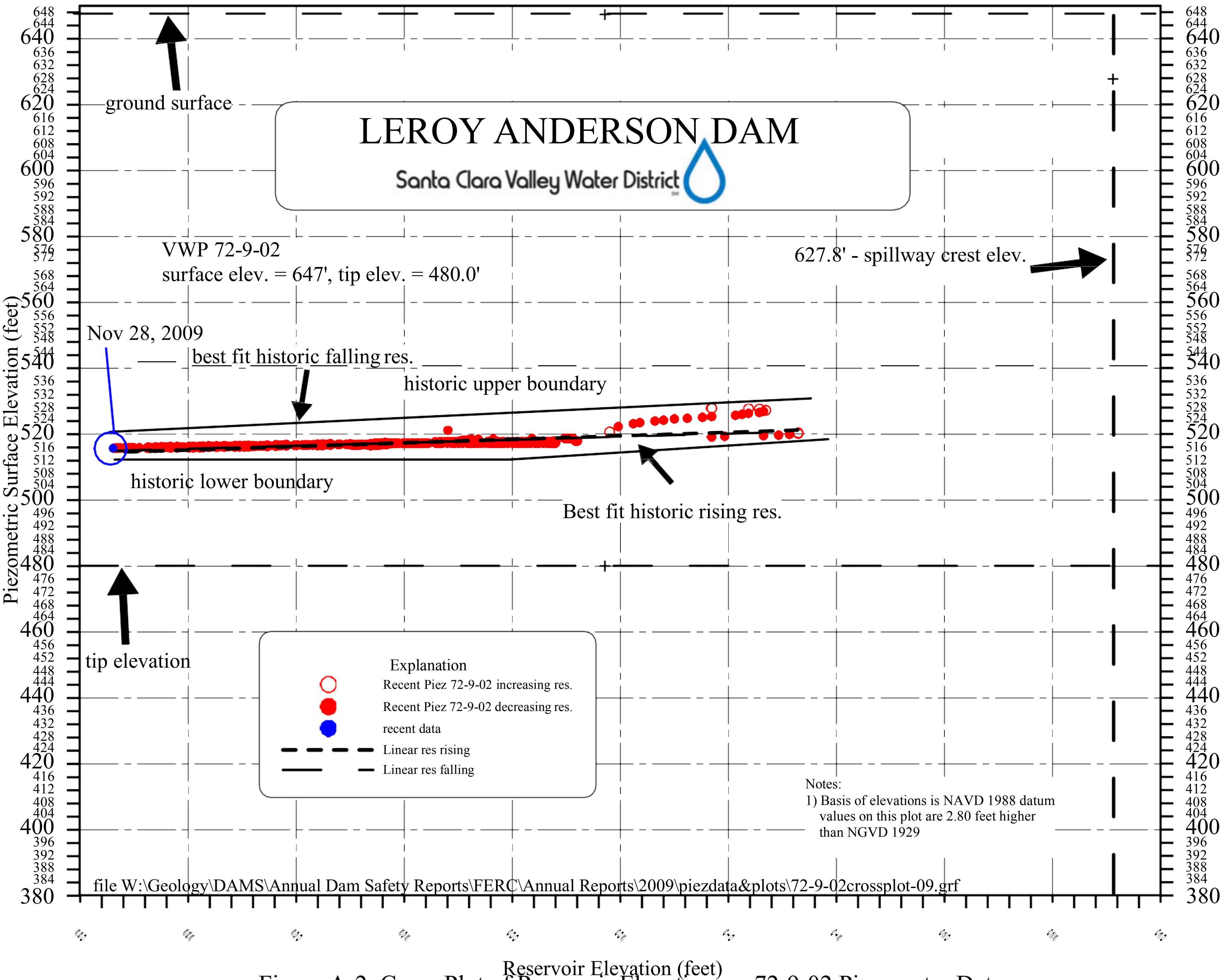
Figure A-35 Cross Plot of Reservoir Elevation versus Spillway Weir Discharge, gpm



Notes:
1) Basis of elevations is NAVD 1988 datum values on this plot are 2.80 feet higher than NGVD 1929

file W:\Geology\DAMS\Annual Dam Safety Reports\FERC\Annual Reports\2009\piezdata&plots\72-9-01crossplot-09.grf

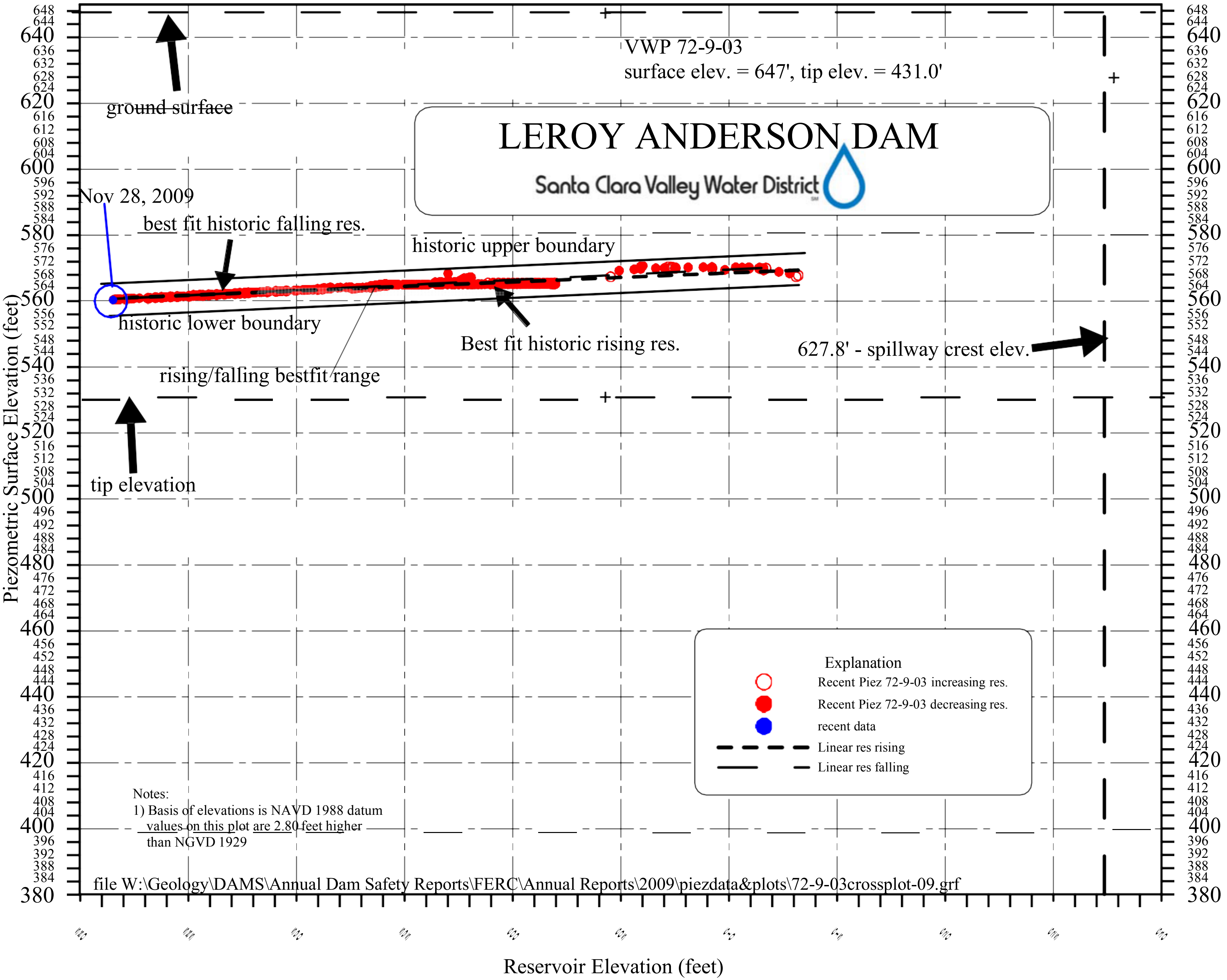
Figure A-1. Cross-Plot of Reservoir Elevation vs. 72-9-02 Piezometer Data



Notes:
1) Basis of elevations is NAVD 1988 datum values on this plot are 2.80 feet higher than NGVD 1929

file W:\Geology\DAMS\Annual Dam Safety Reports\FERC\Annual Reports\2009\piezdata&plots\72-9-02crossplot-09.grf

Figure A-2. Cross-Plot of Reservoir Elevation vs. 72-9-02 Piezometer Data



Notes:
1) Basis of elevations is NAVD 1988 datum
values on this plot are 2.80 feet higher
than NGVD 1929

file W:\Geology\DAMS\Annual Dam Safety Reports\FERC\Annual Reports\2009\piezdata&plots\72-9-03crossplot-09.grf

Figure A-3. Cross-Plot of Reservoir Elevation vs. 72-9-05 Piezometer Data

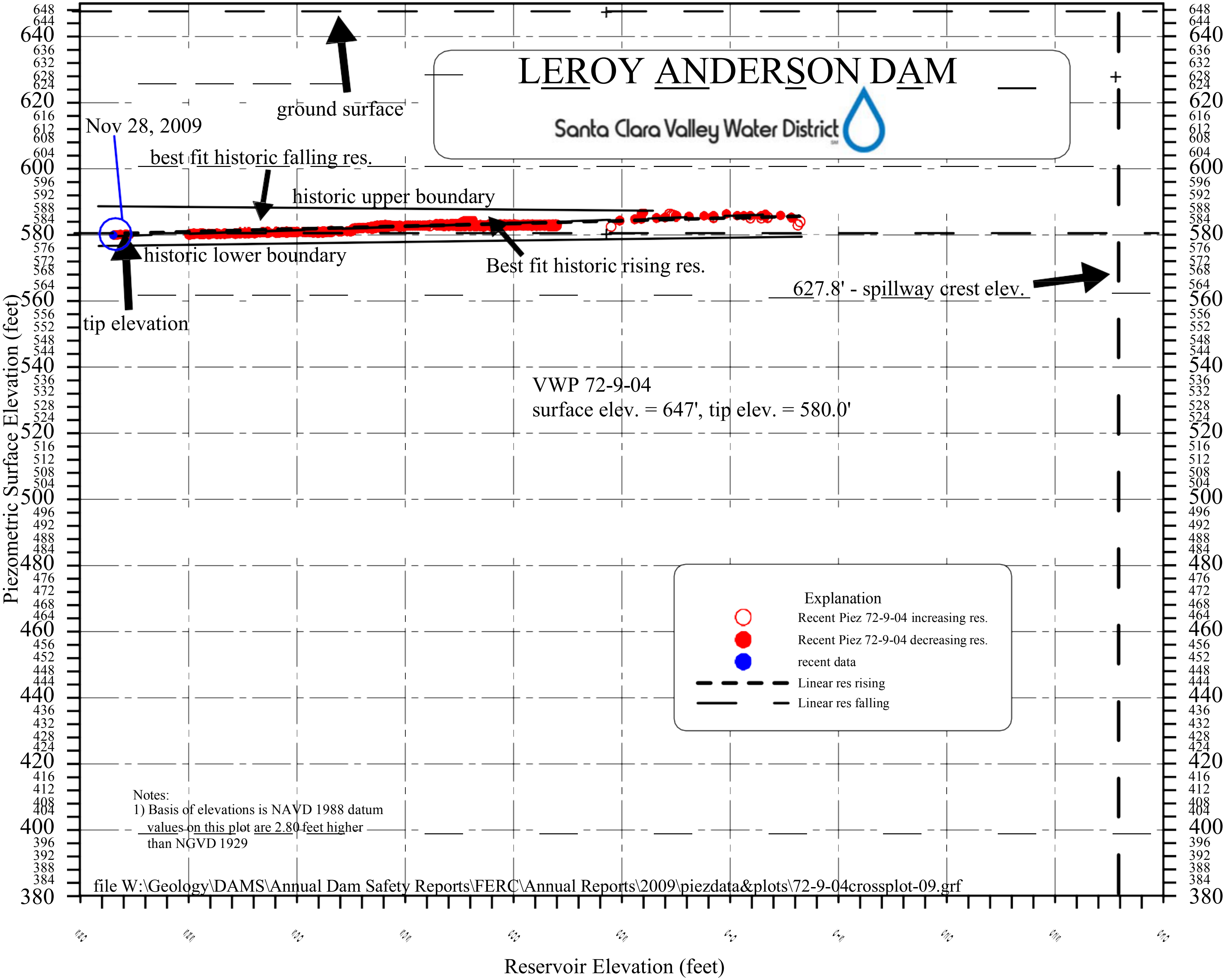


Figure A-4. Cross-Plot of Reservoir Elevation vs. 72-9-05 Piezometer Data

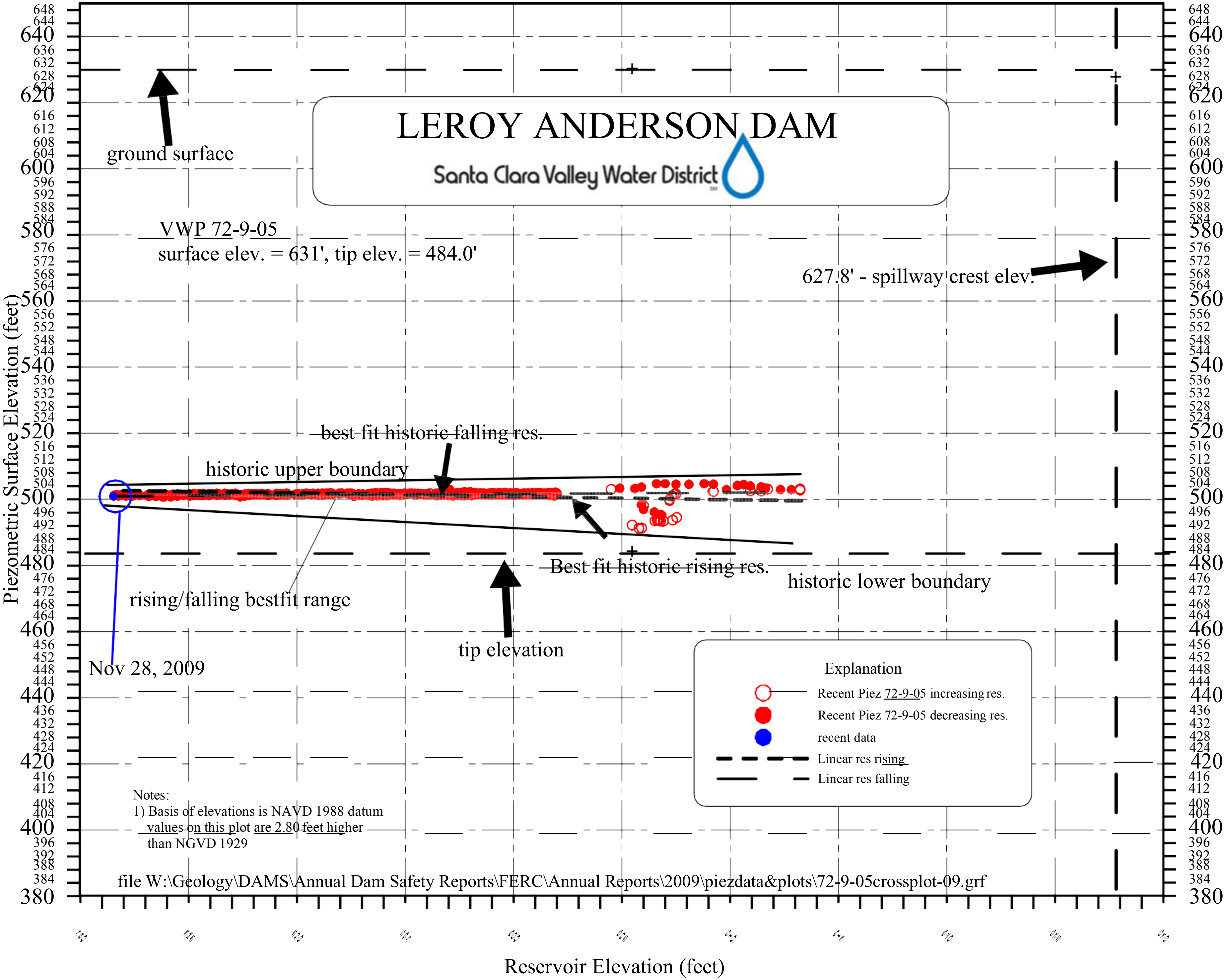


Figure A-5. Cross-Plot of Reservoir Elevation vs. 72-9-05 Piezometer Data

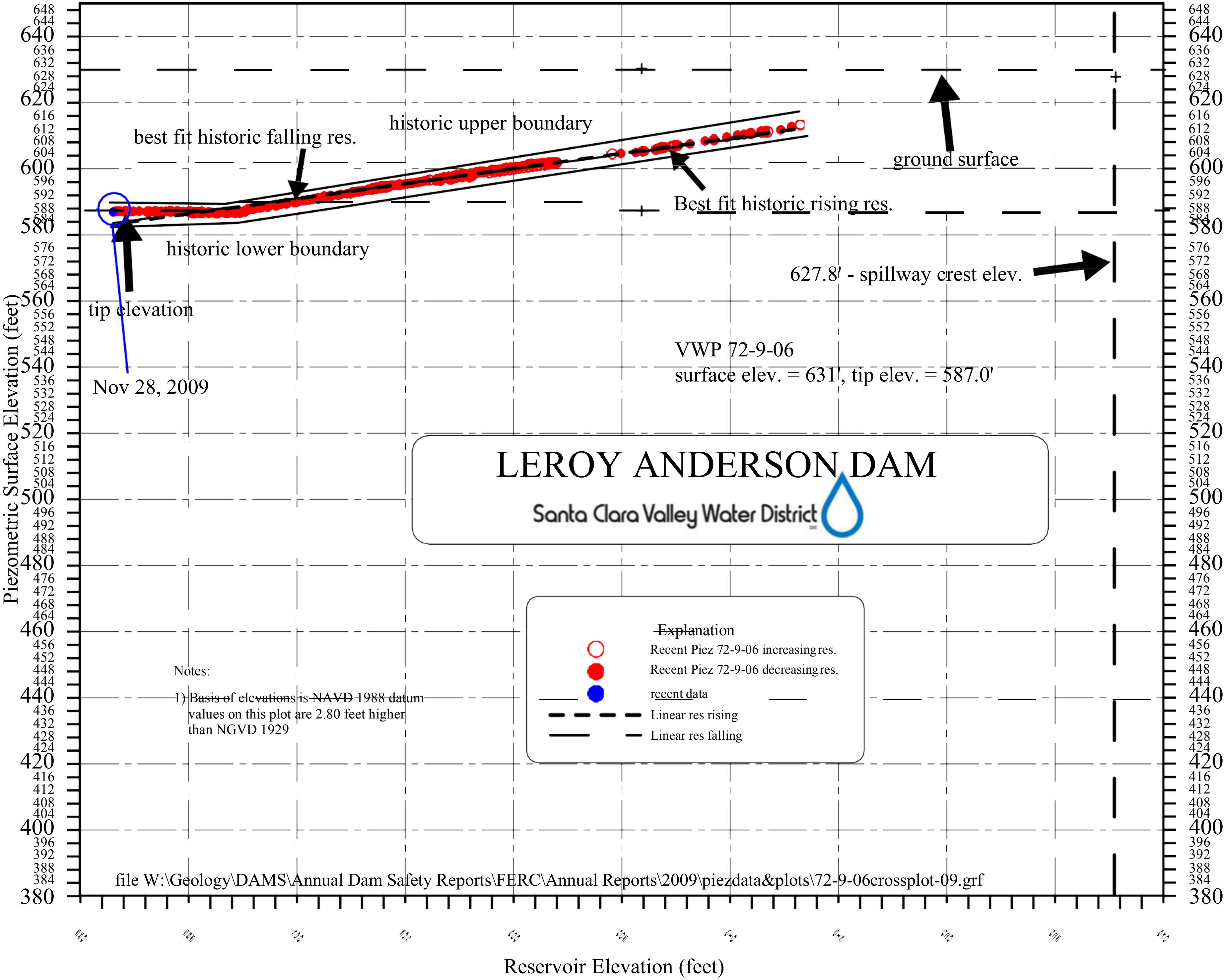


Figure A-6. Cross-Plot of Reservoir Elevation vs. 72-9-06 Piezometer Data

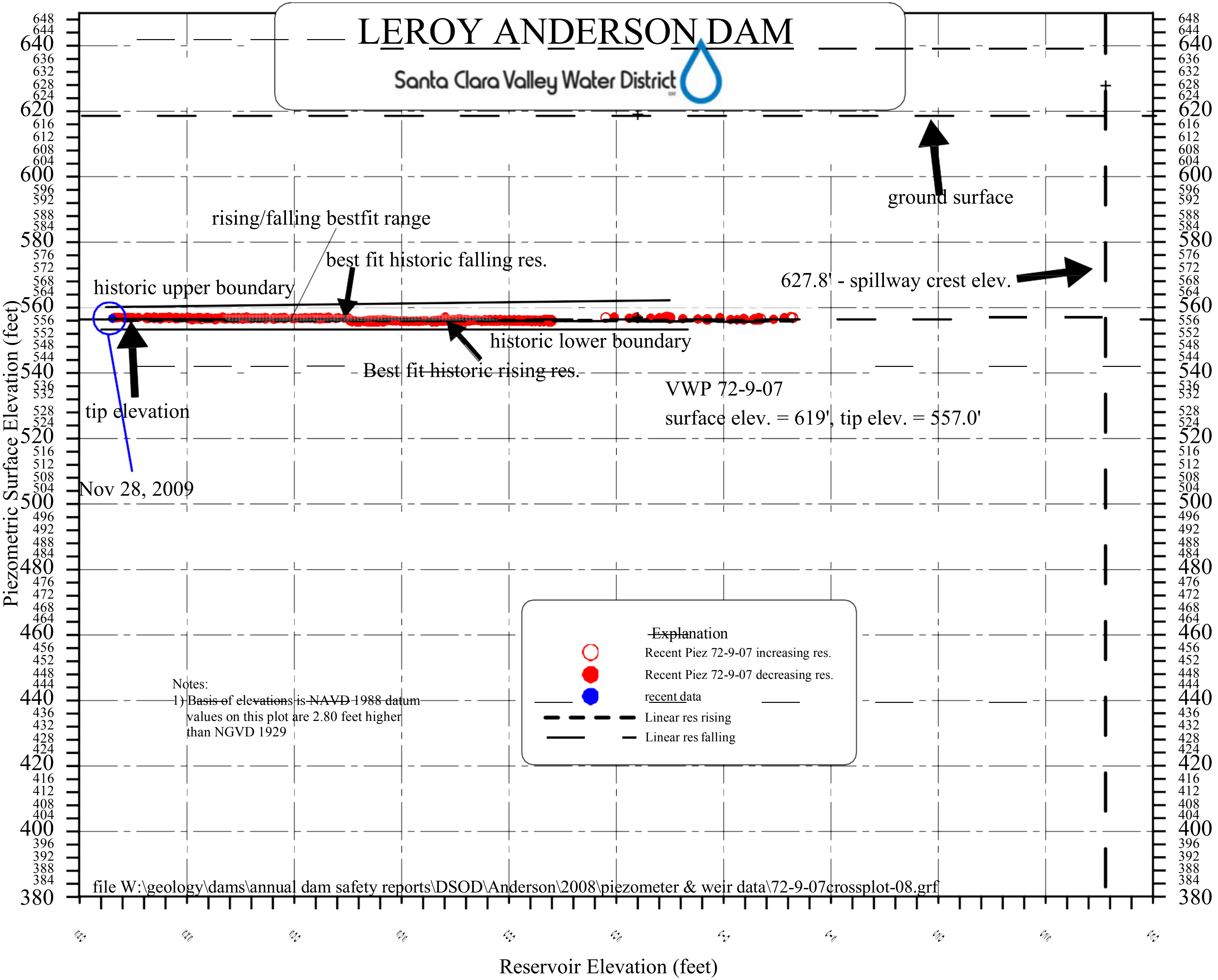


Figure A-7. Cross-Plot of Reservoir Elevation vs. 72-9-06 Piezometer Data

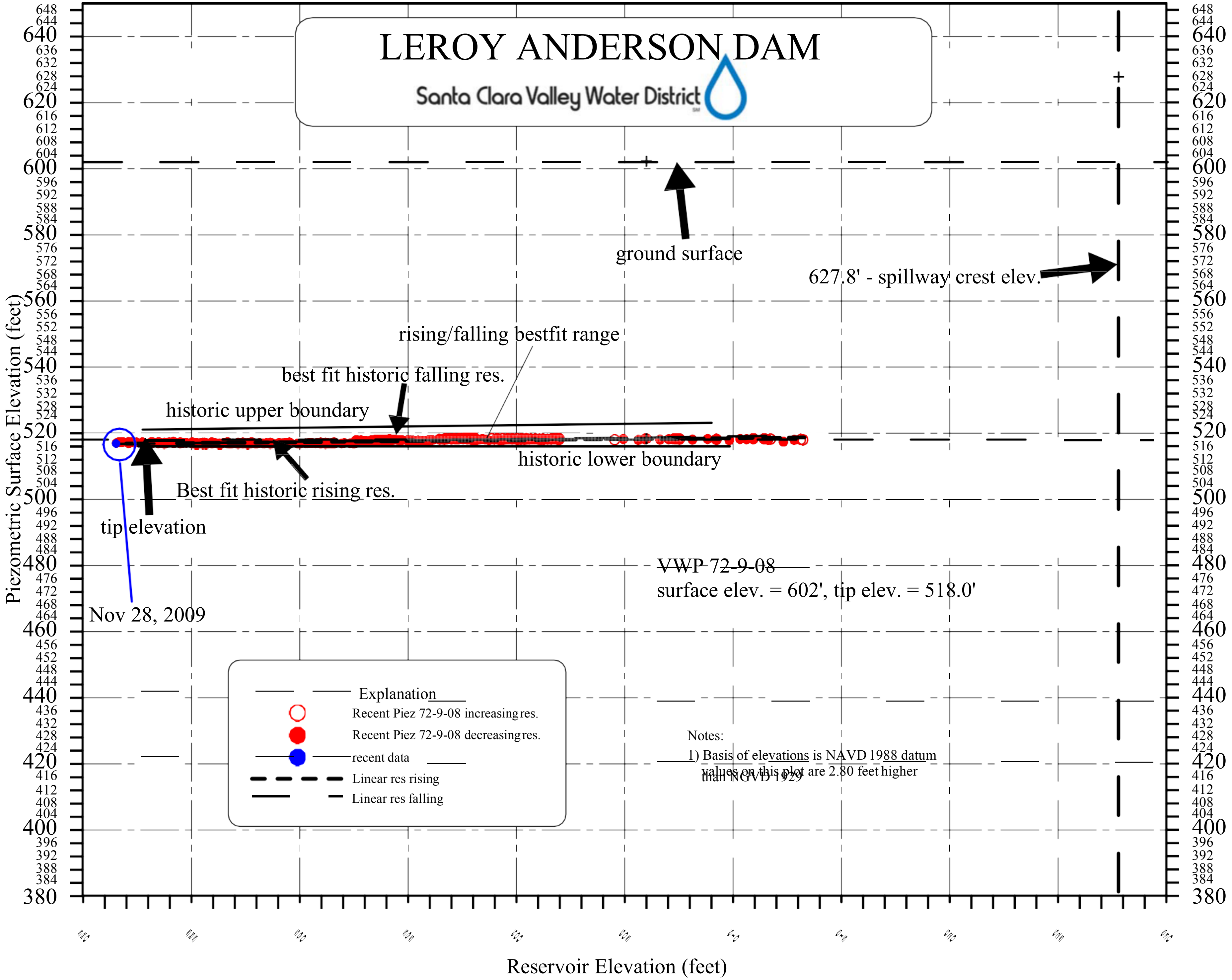


Figure A-8. Cross-Plot of Reservoir Elevation vs. 72-9-06 Piezometer Data

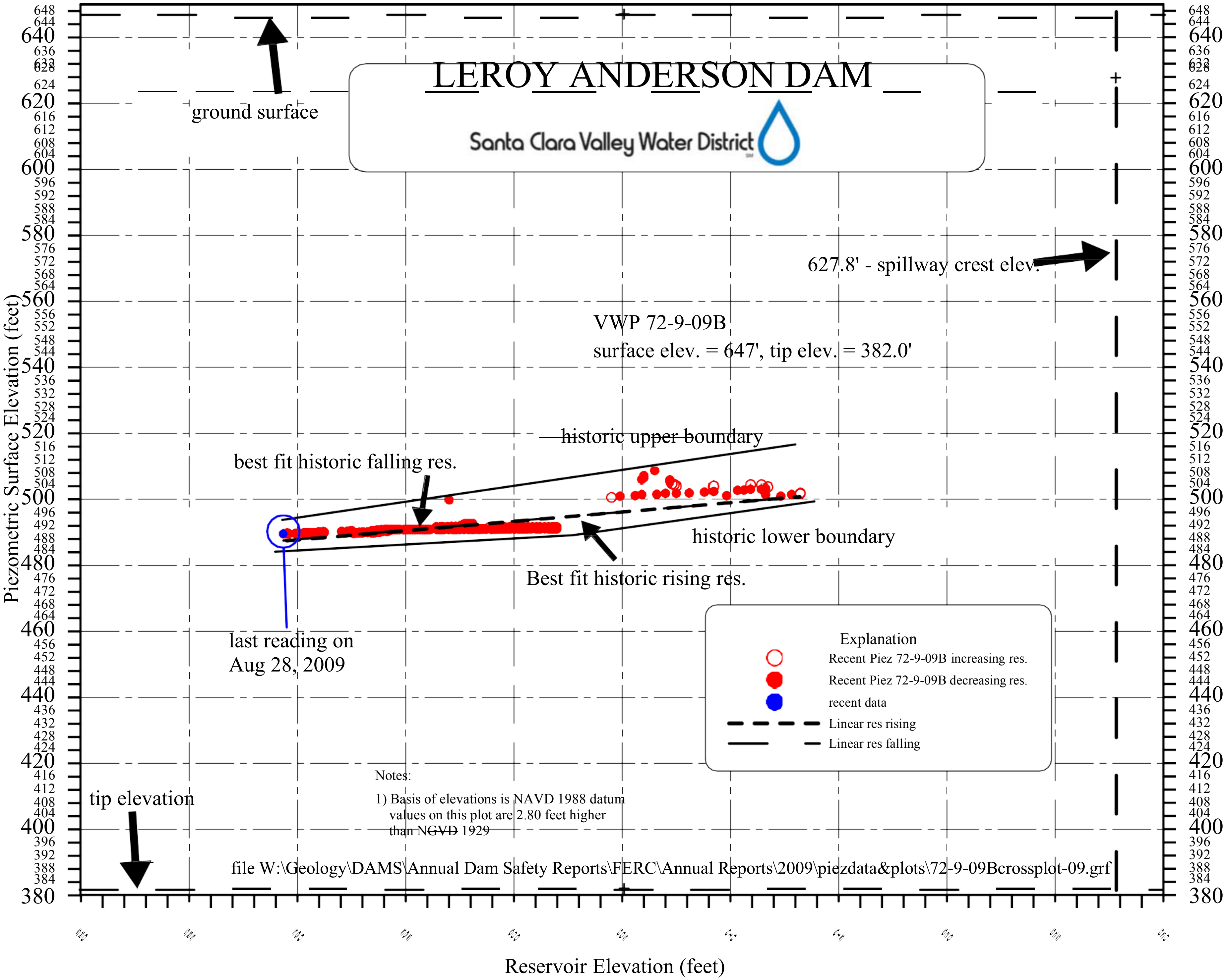


Figure A-9. Cross-Plot of Reservoir Elevation vs. 72-9-09B Piezometer Data

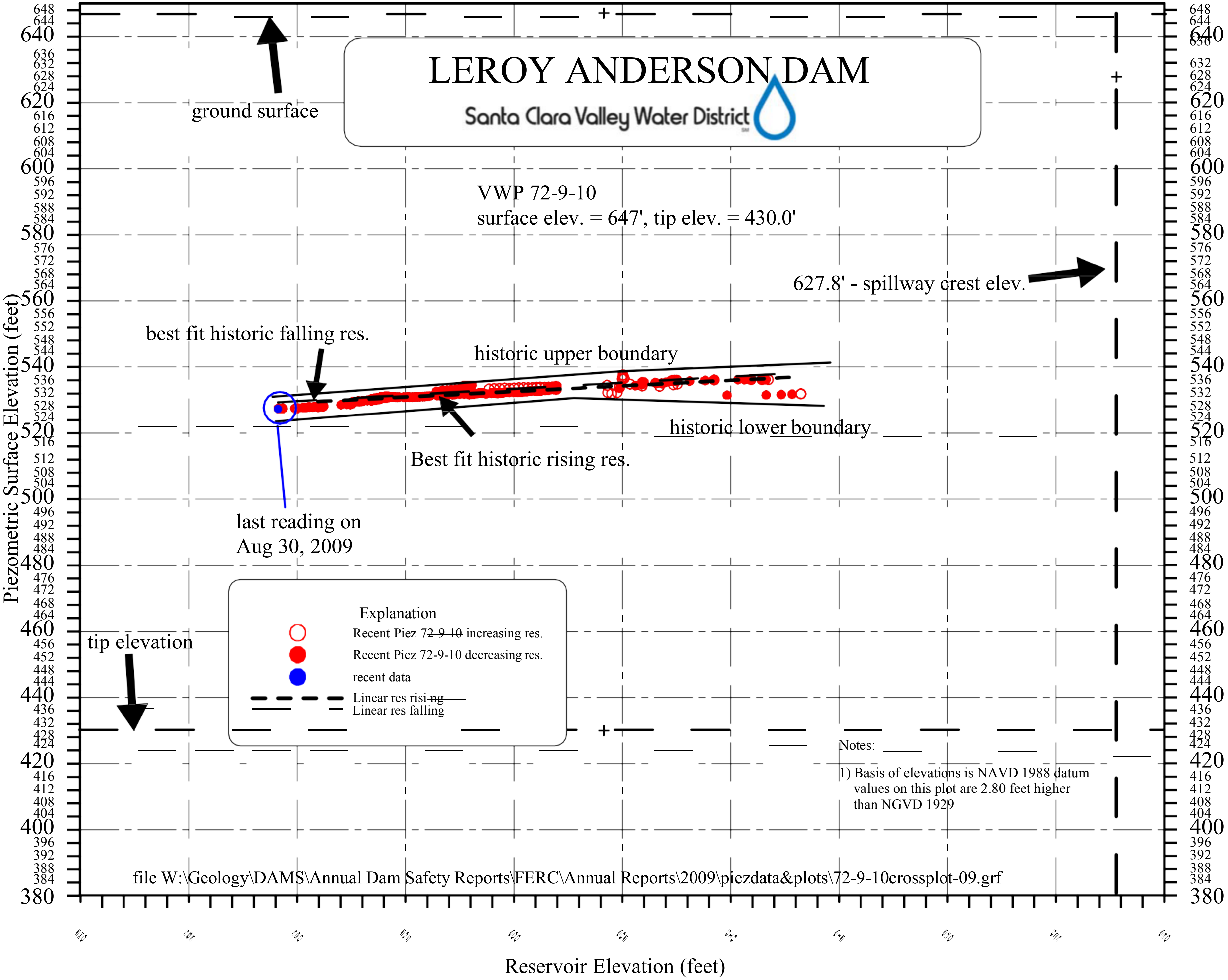


Figure A-10. Cross-Plot of Reservoir Elevation vs. 72-9-11 Piezometer Data

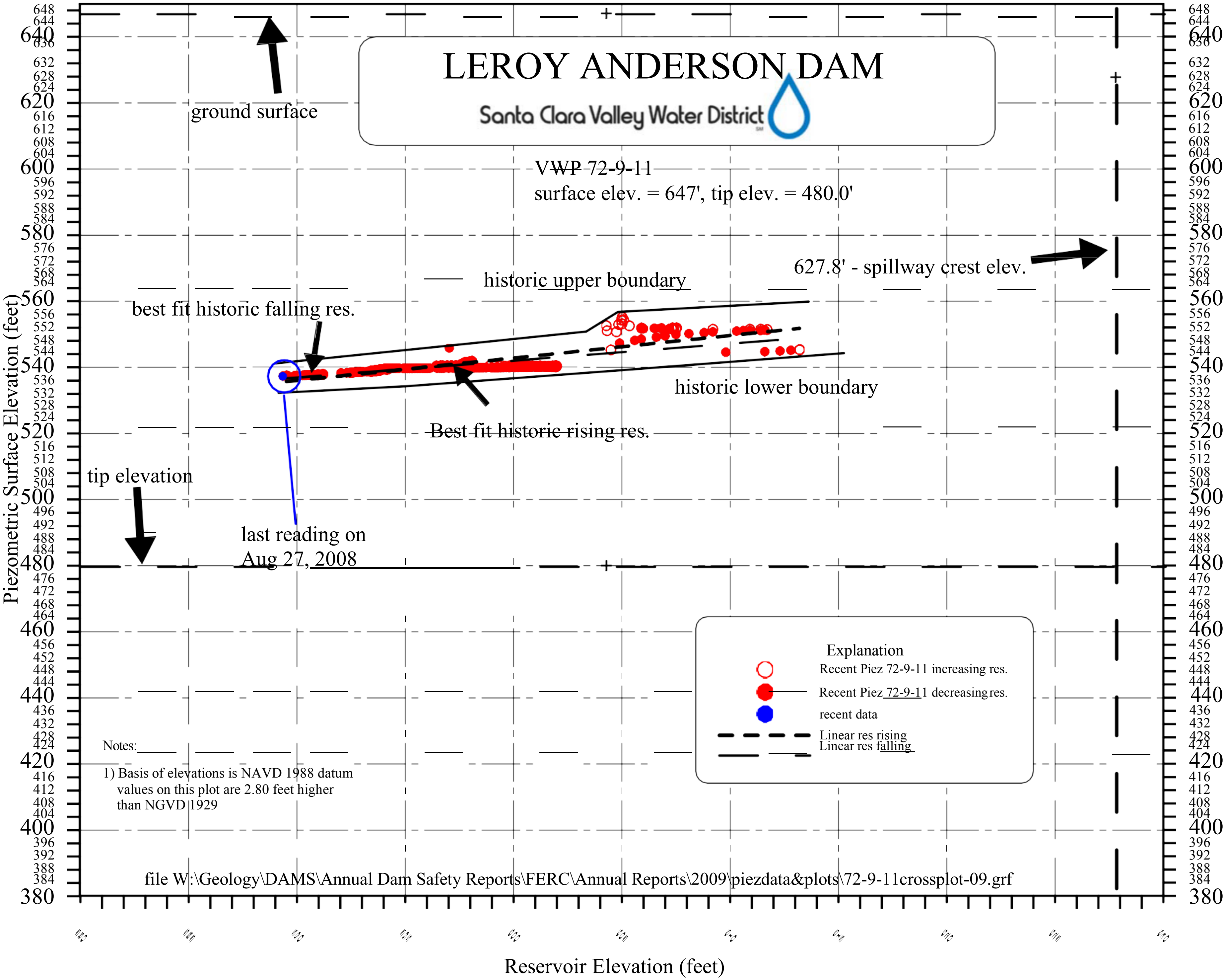


Figure A-11. Cross-Plot of Reservoir Elevation vs. 72-9-11 Piezometer Data

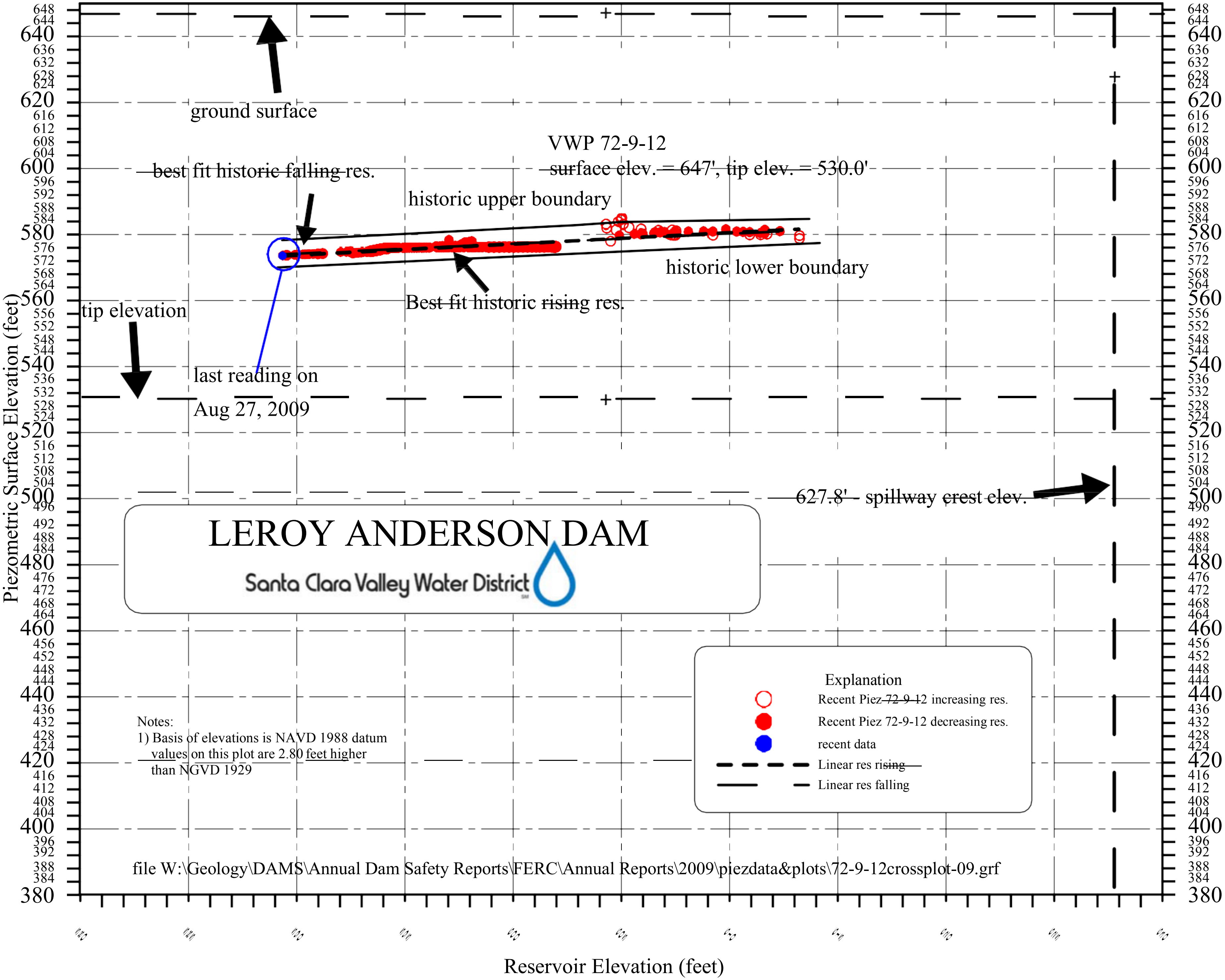
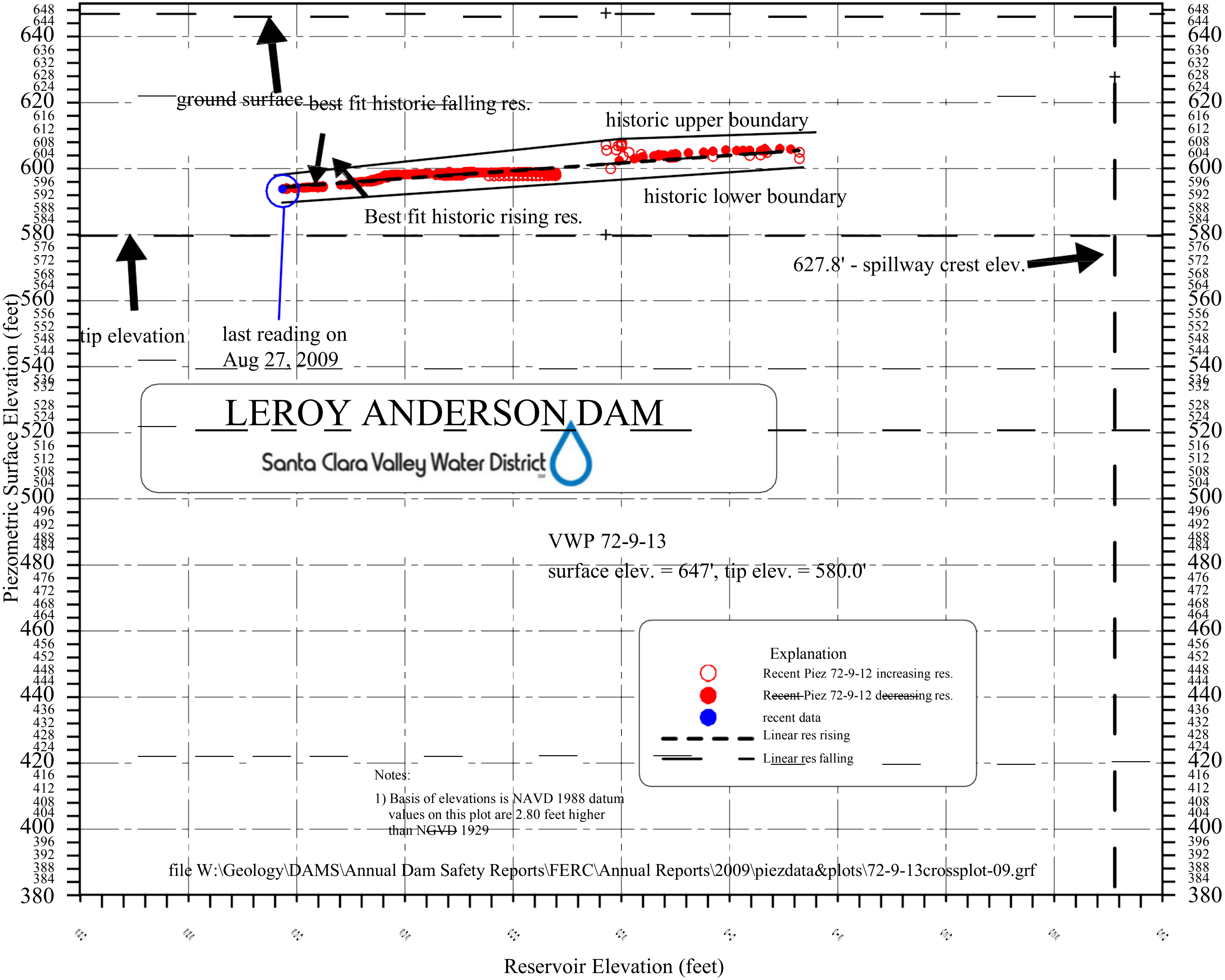


Figure A-12. Cross-Plot of Reservoir Elevation vs. 72-9-11 Piezometer Data



Notes:

1) Basis of elevations is NAVD 1988 datum
values on this plot are 2.80 feet higher
than NGVD 1929

file W:\Geology\DAMS\Annual Dam Safety Reports\FERC\Annual Reports\2009\piezdata&plots\72-9-13crossplot-09.grf

Figure A-13. Cross-Plot of Reservoir Elevation vs. 72-9-11 Piezometer Data

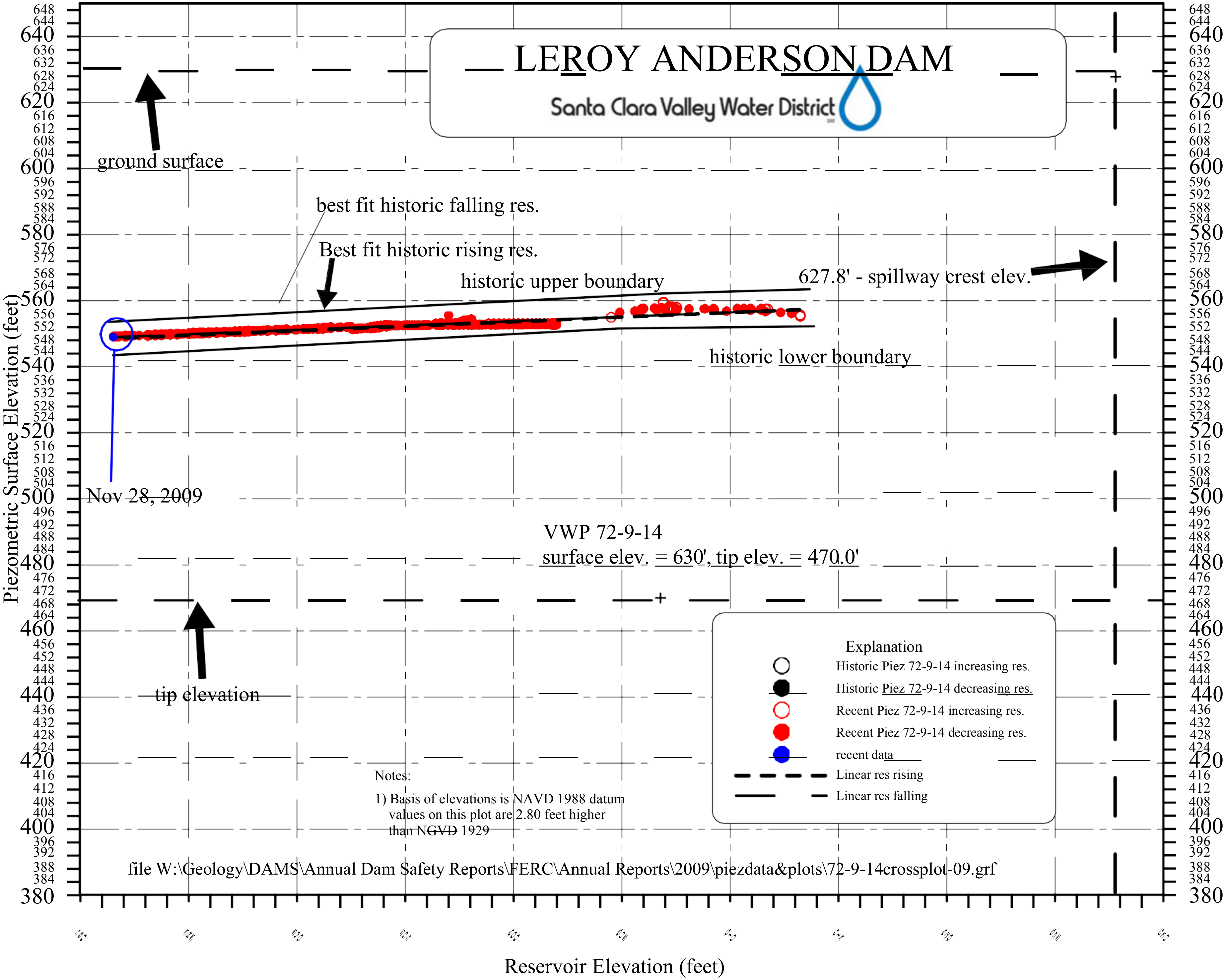


Figure A-14. Cross-Plot of Reservoir Elevation vs. 72-9-11 Piezometer Data

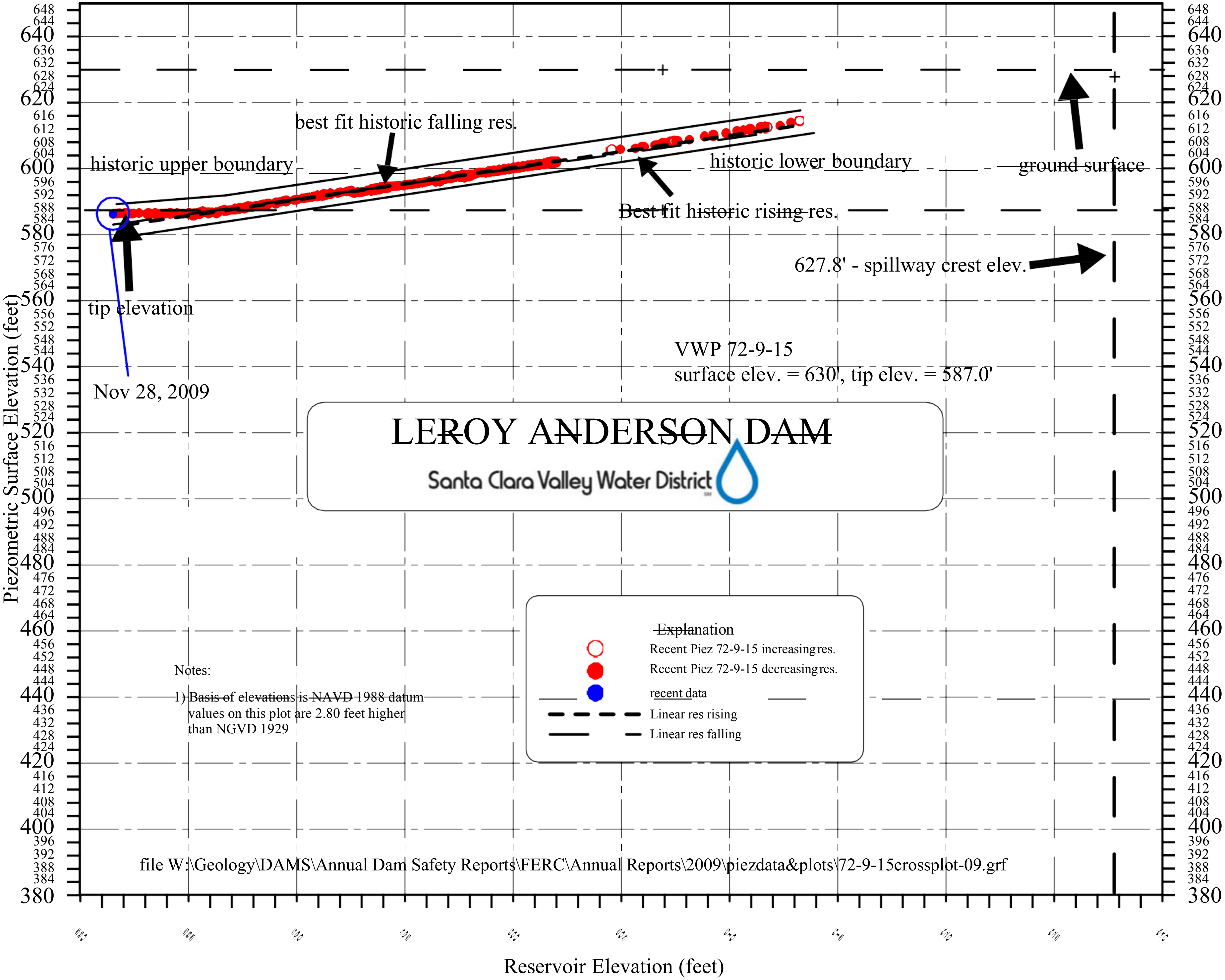


Figure A-15. Cross-Plot of Reservoir Elevation vs. 72-9-11 Piezometer Data

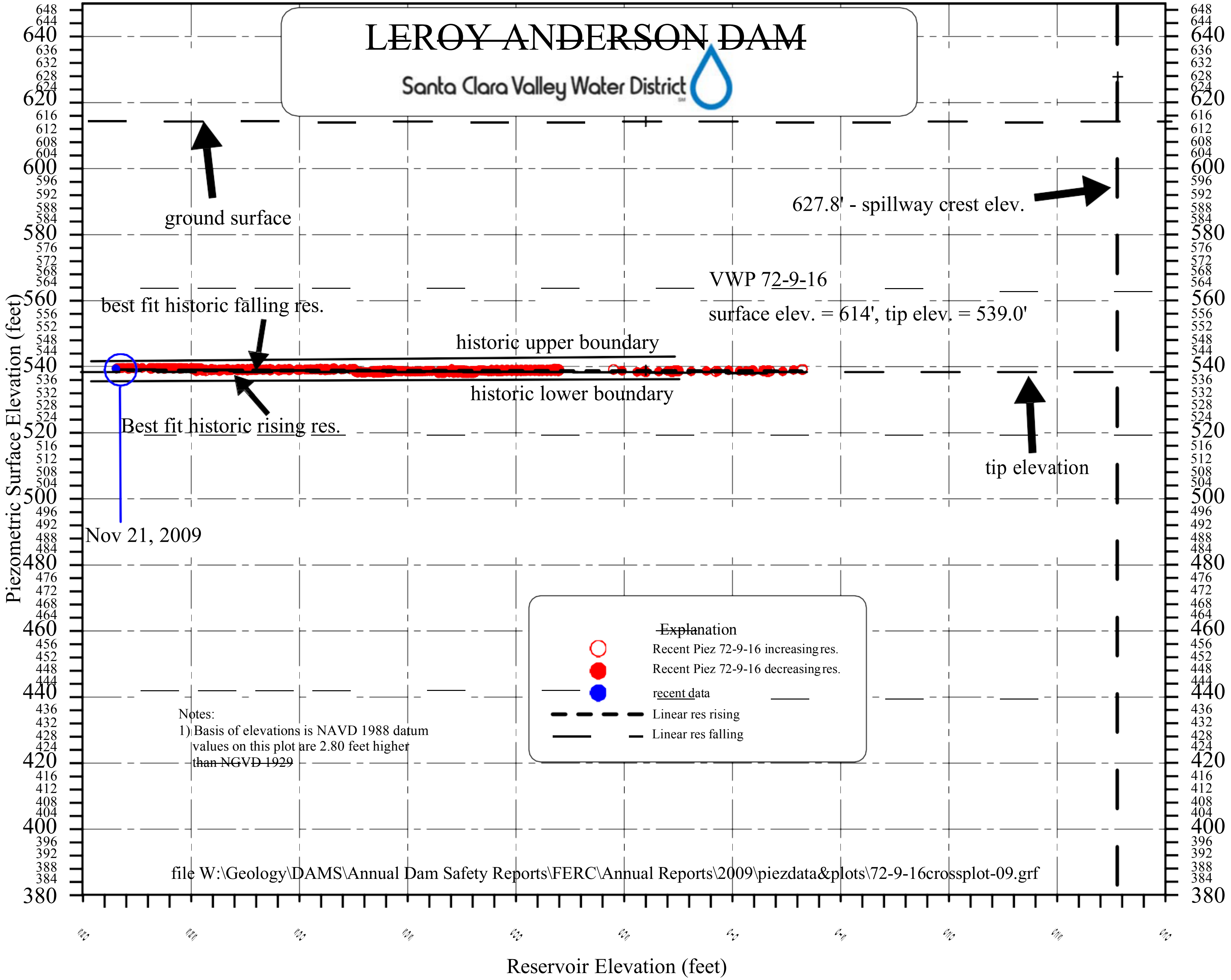


Figure A-16. Cross-Plot of Reservoir Elevation vs. 72-9-11 Piezometer Data

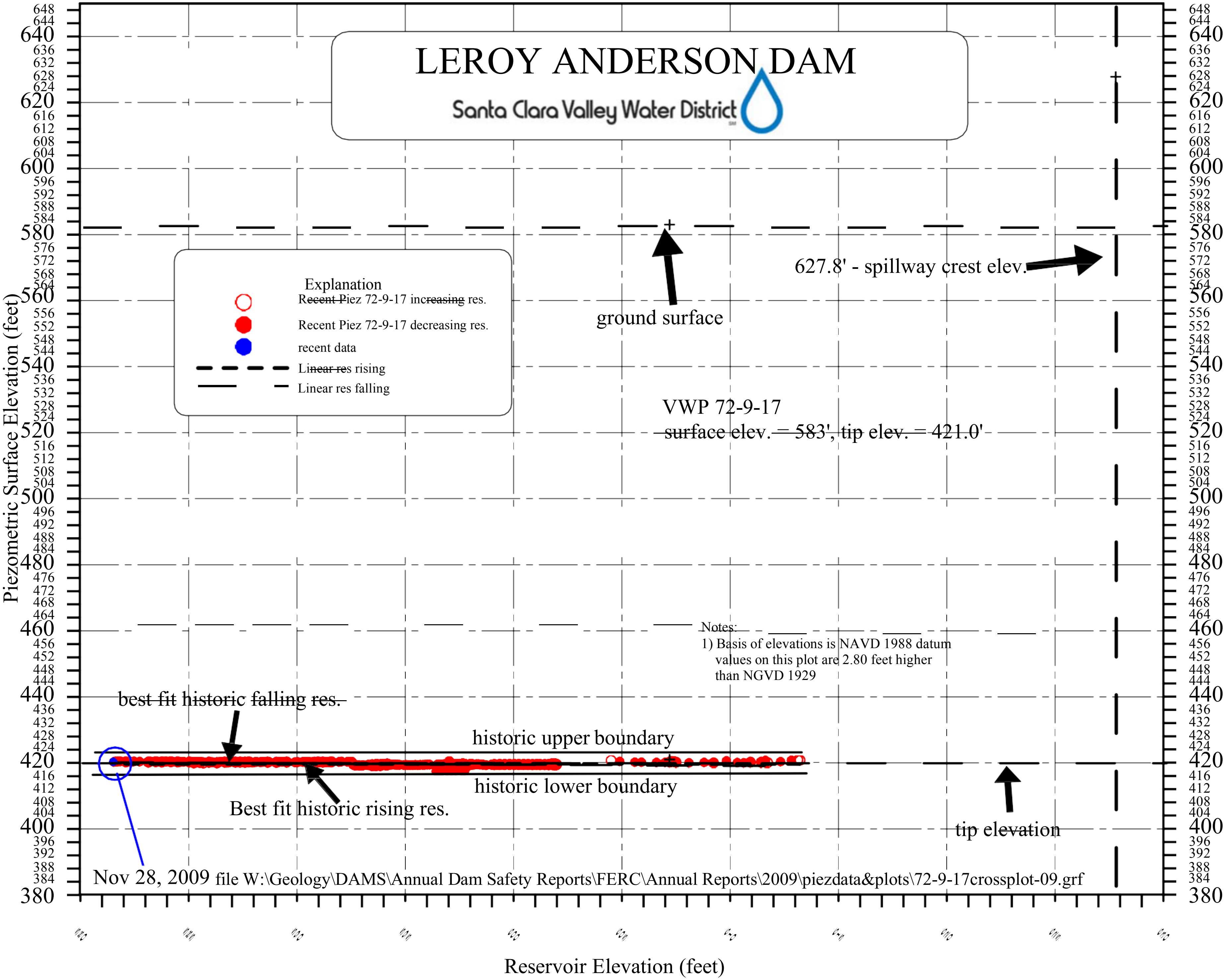


Figure A-17. Cross-Plot of Reservoir Elevation vs. 72-9-11 Piezometer Data

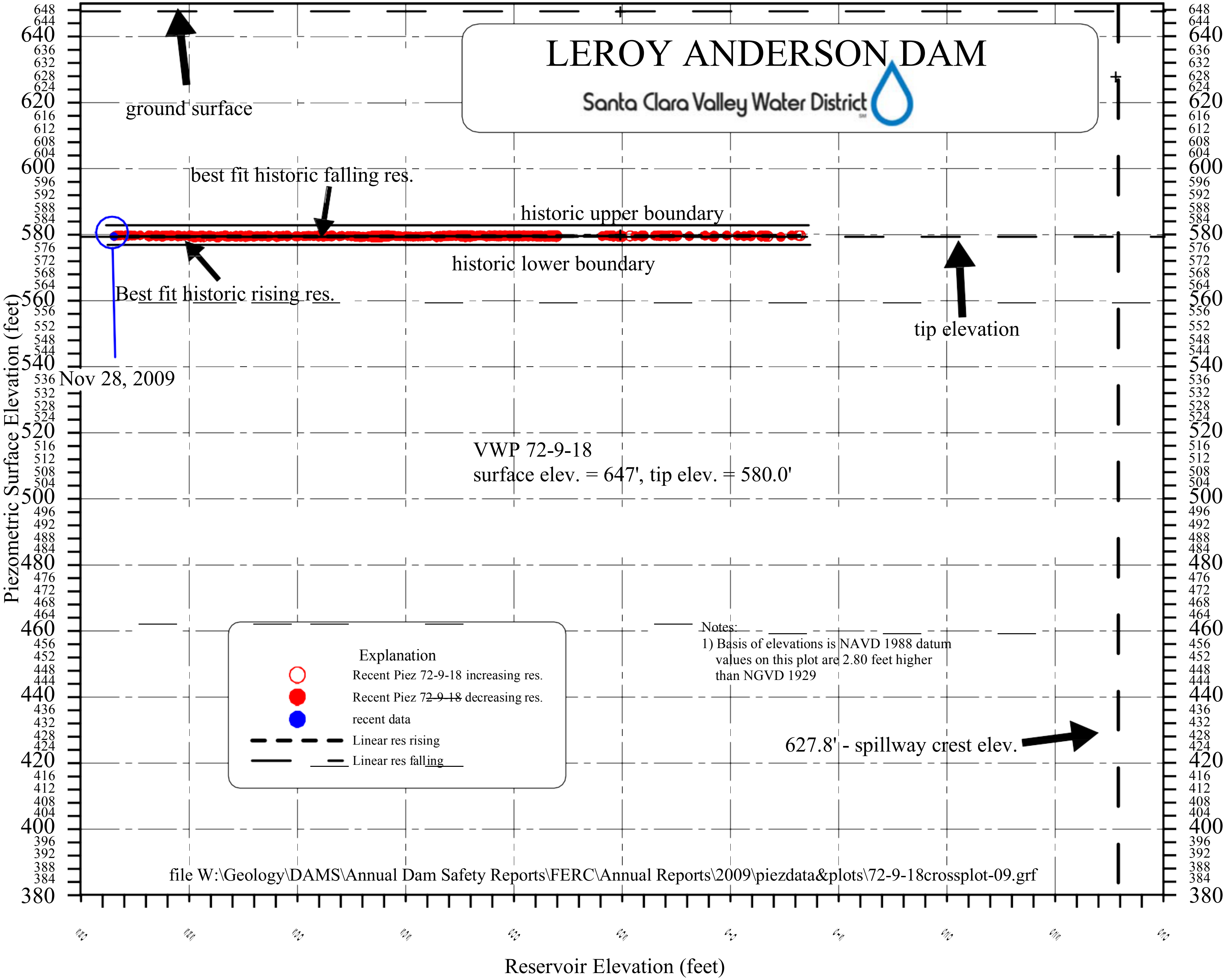


Figure A-18. Cross-Plot of Reservoir Elevation vs. 72-9-11 Piezometer Data

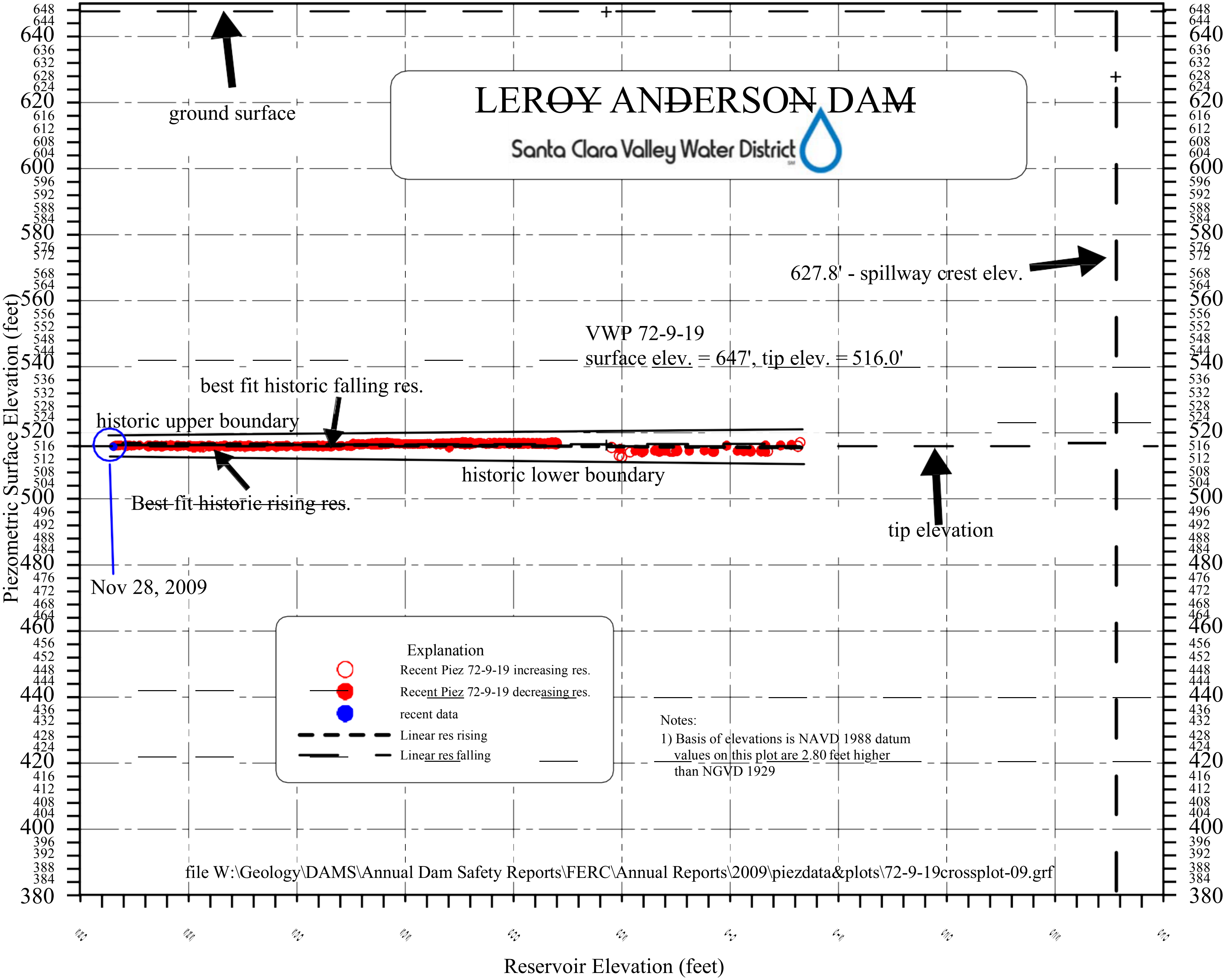
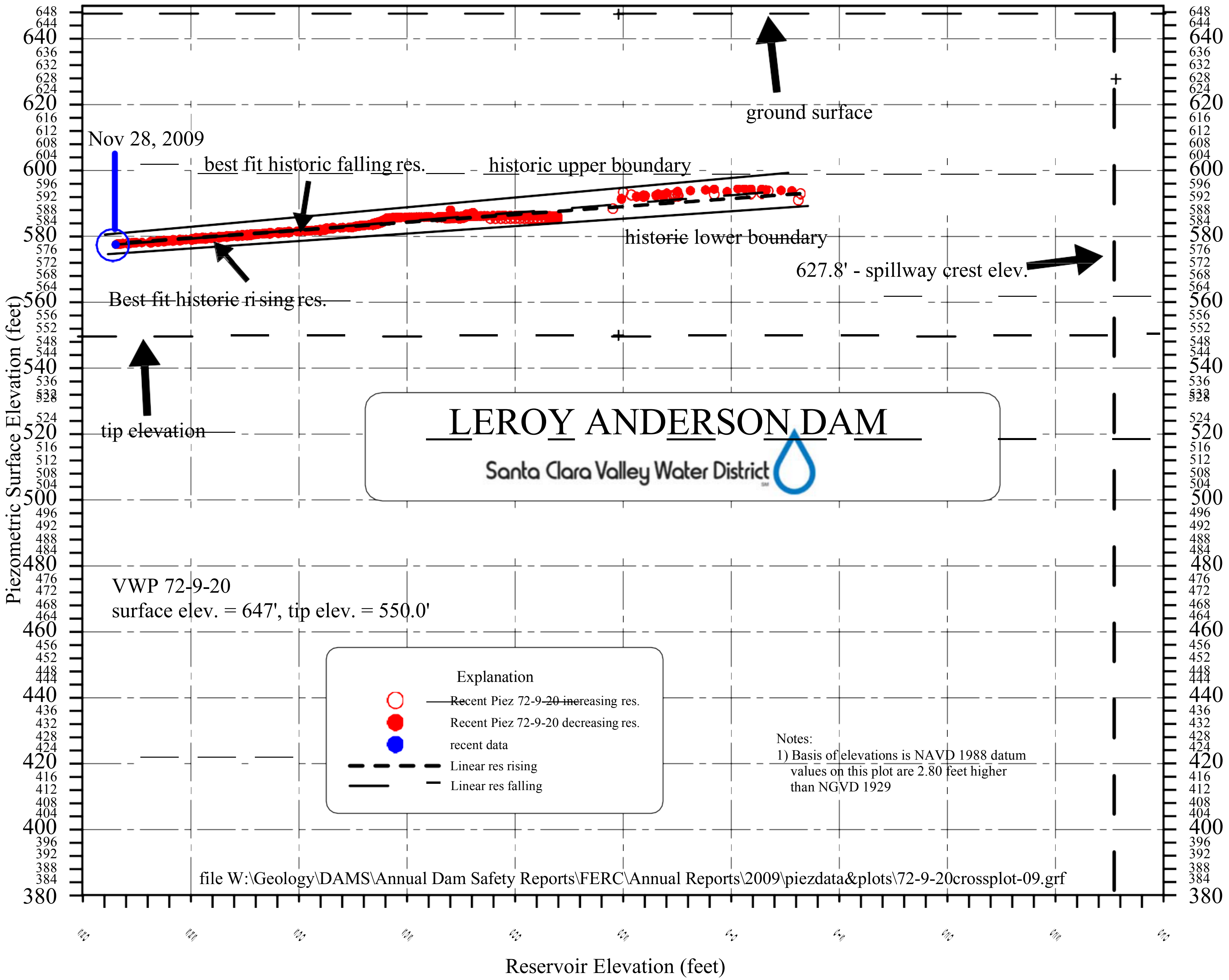


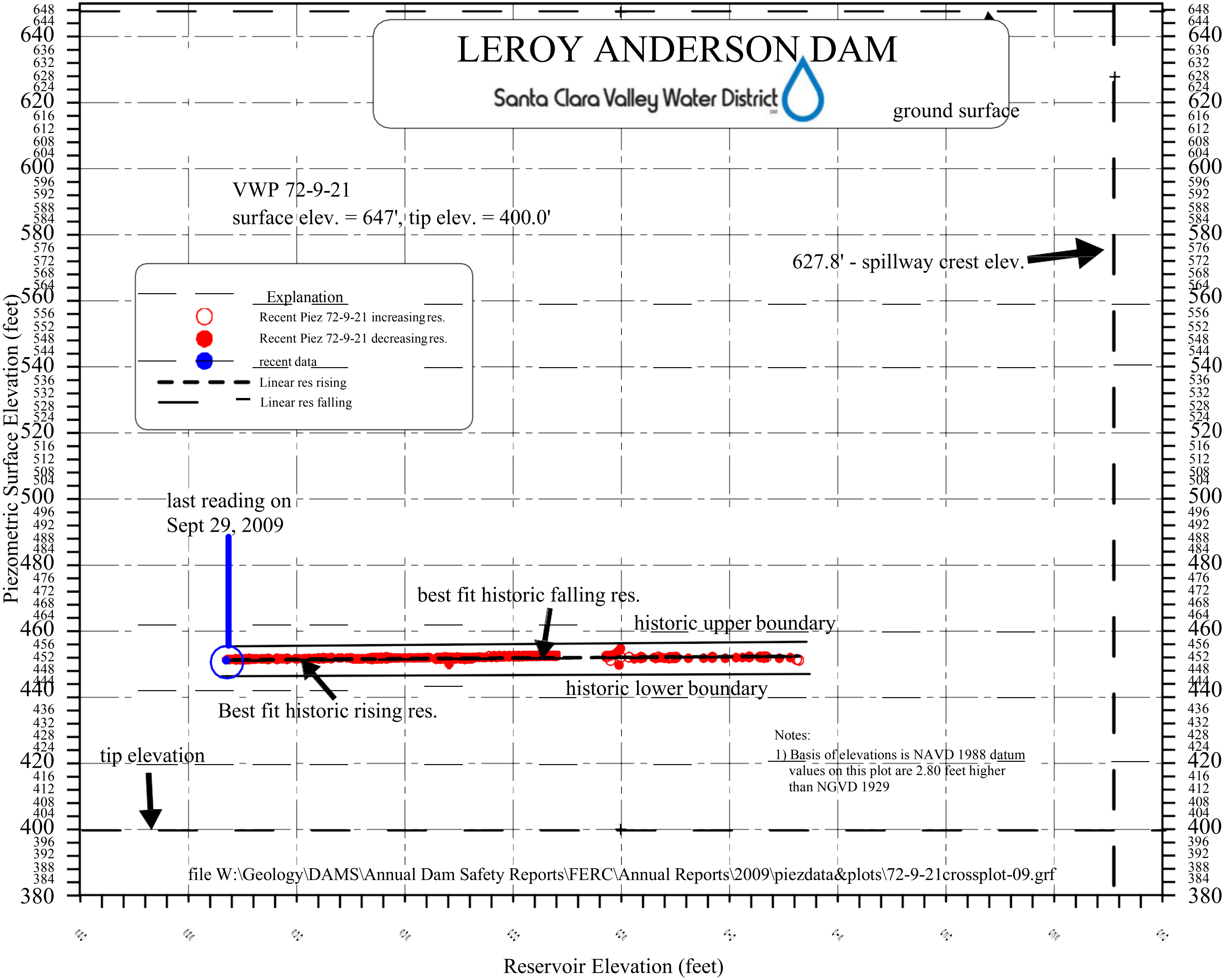
Figure A-19. Cross-Plot of Reservoir Elevation vs. 72-9-19 Piezometer Data



Notes:
1) Basis of elevations is NAVD 1988 datum values on this plot are 2.80 feet higher than NGVD 1929

file W:\Geology\DAMS\Annual Dam Safety Reports\FERC\Annual Reports\2009\piezdata&plots\72-9-20crossplot-09.grf

Figure A-20. Cross-Plot of Reservoir Elevation vs. 72-9-21 Piezometer Data



Notes:
1) Basis of elevations is NAVD 1988 datum
values on this plot are 2.80 feet higher
than NGVD 1929

file W:\Geology\DAMS\Annual Dam Safety Reports\FERC\Annual Reports\2009\piezdata&plots\72-9-21crossplot-09.grf

Figure A-21. Cross-Plot of Reservoir Elevation vs. 72-9-21 Piezometer Data

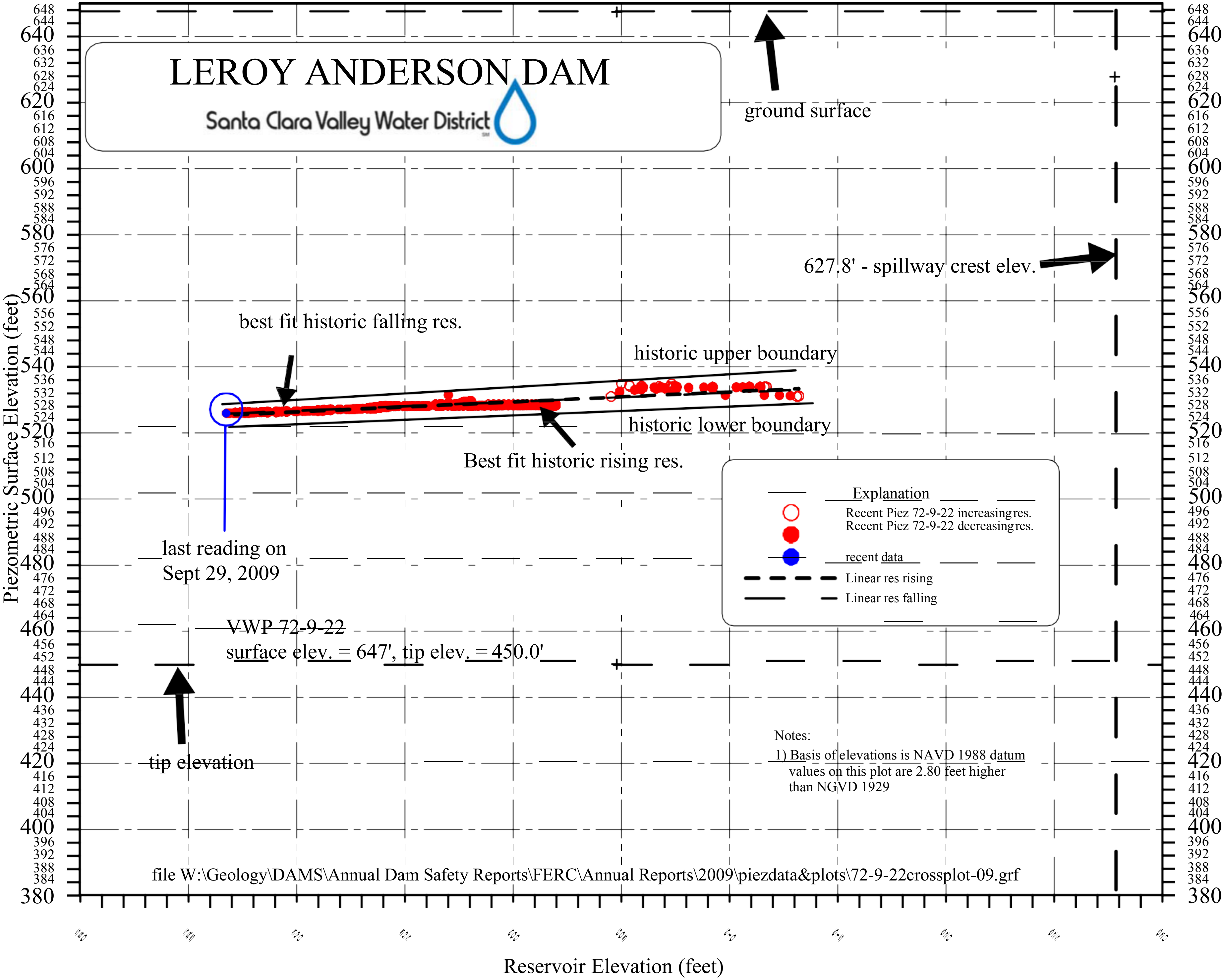


Figure A-22. Cross-Plot of Reservoir Elevation vs. 72-9-21 Piezometer Data

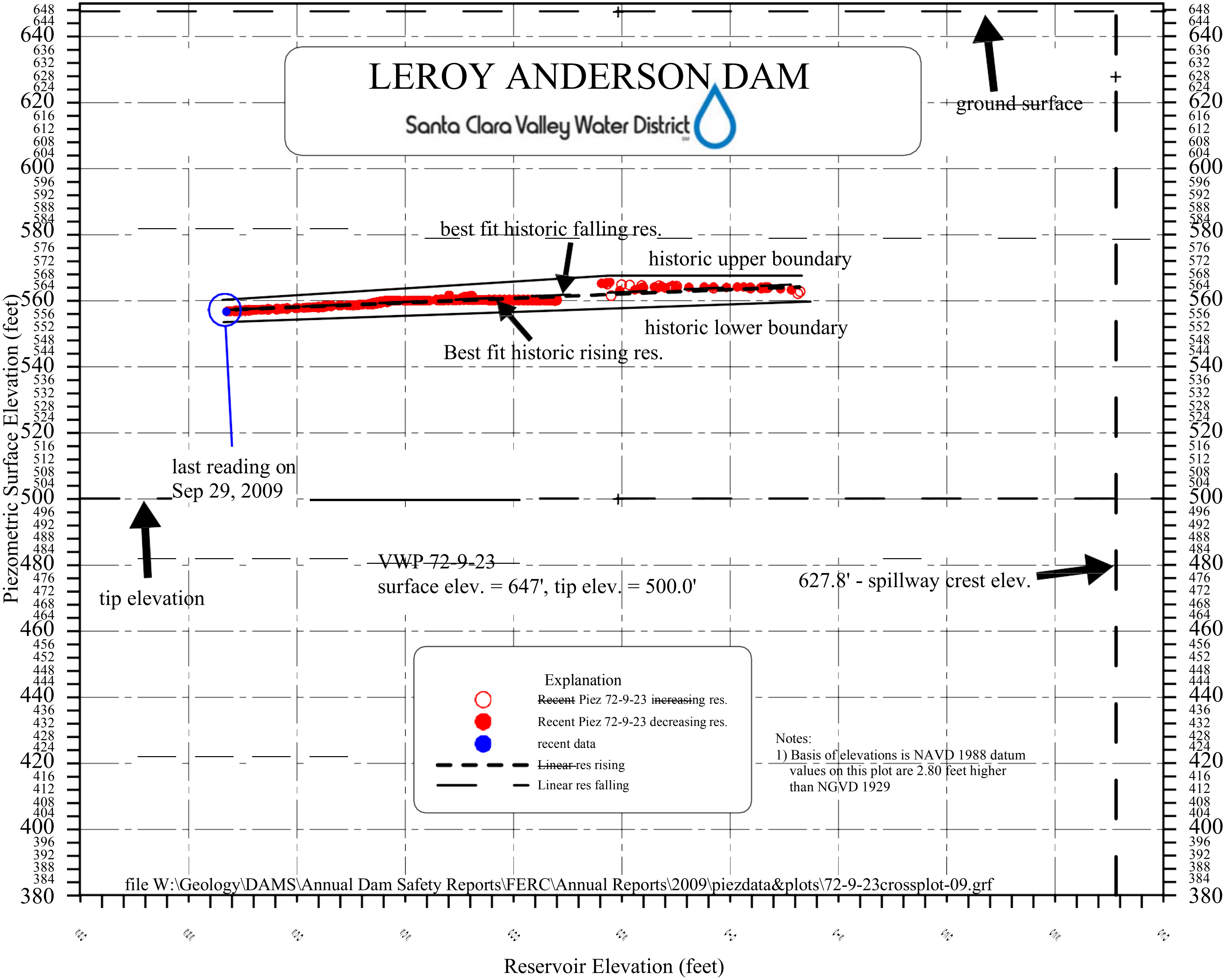


Figure A-23. Cross-Plot of Reservoir Elevation vs. 72-9-21 Piezometer Data

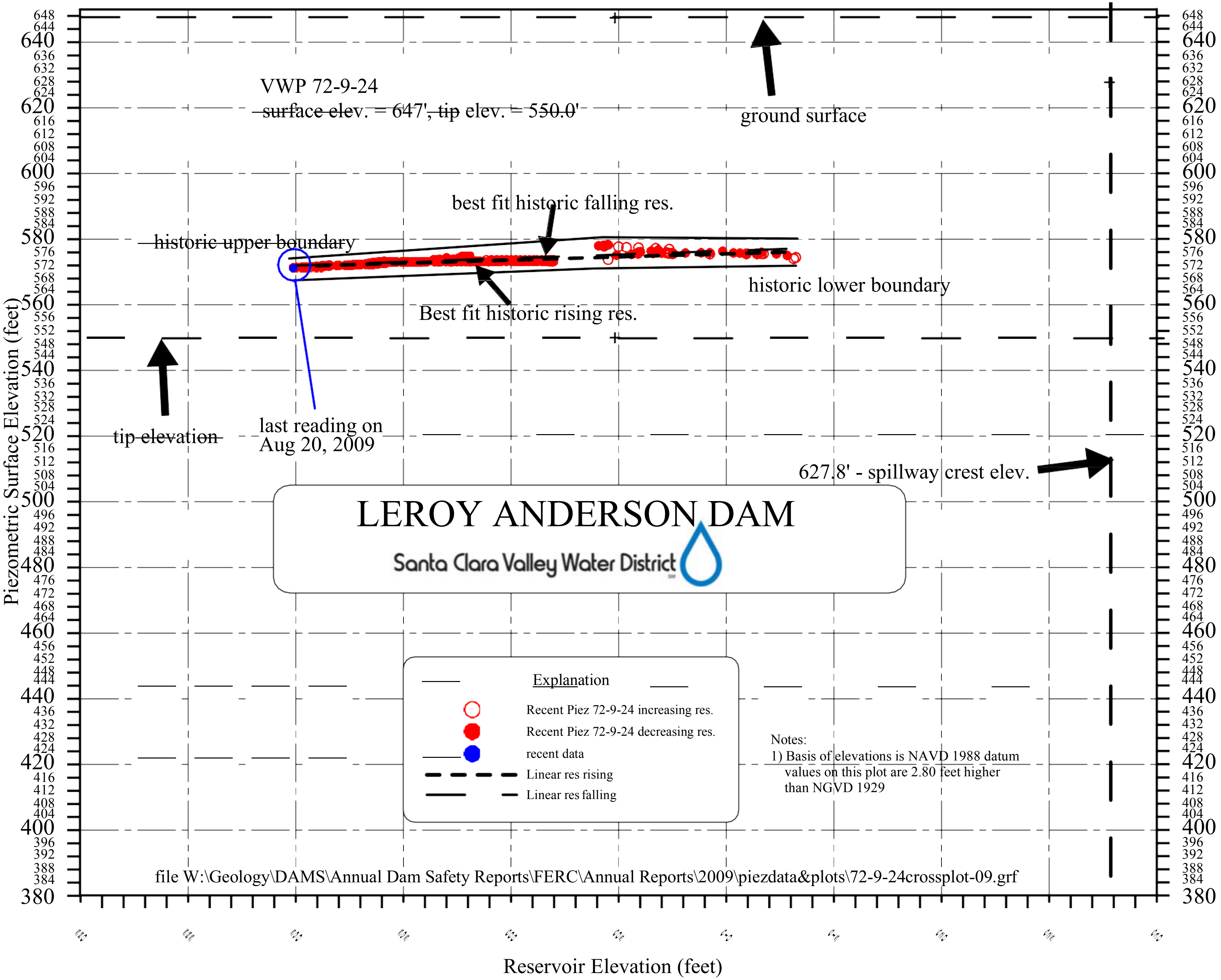


Figure A-24. Cross-Plot of Reservoir Elevation vs. 72-9-21 Piezometer Data

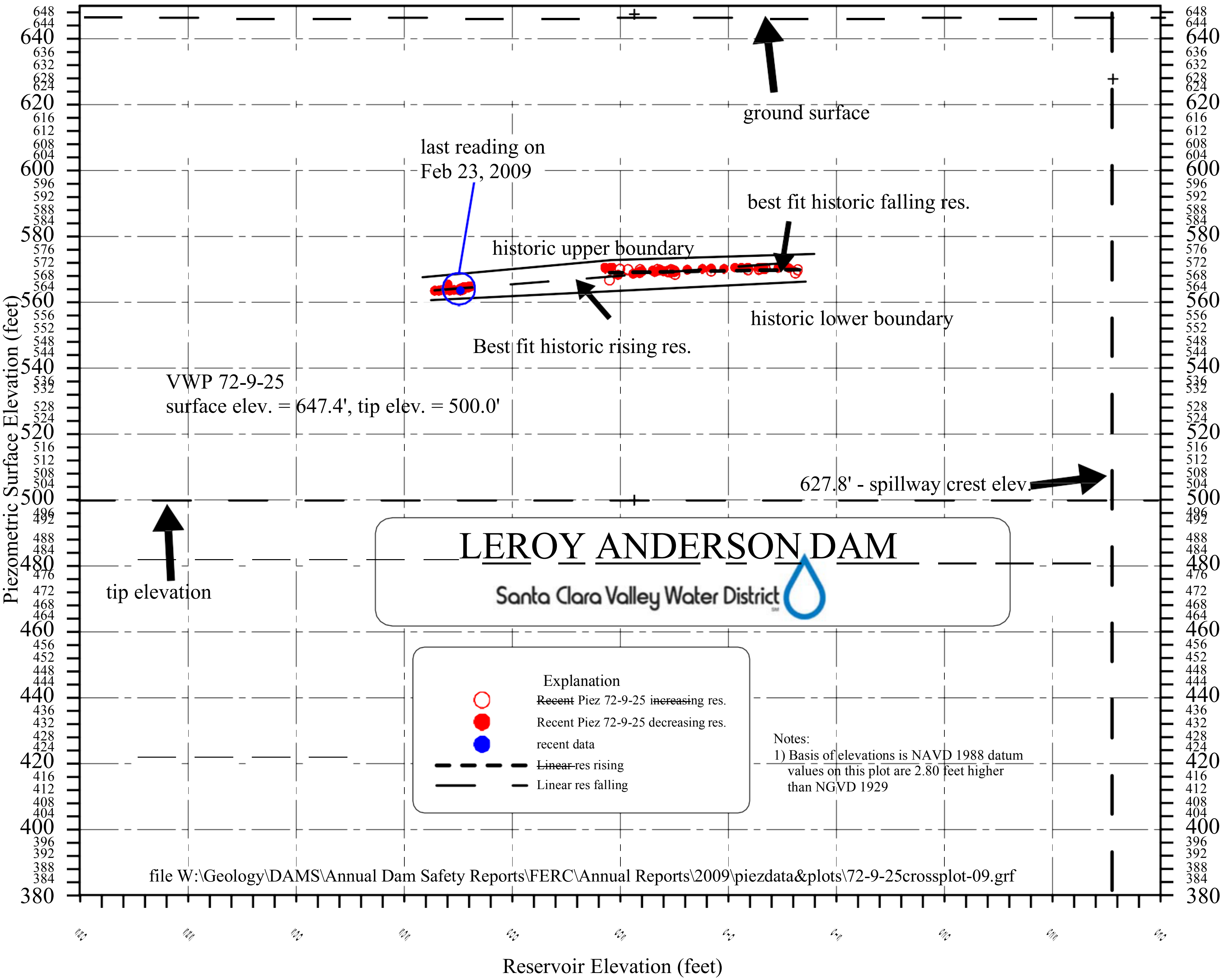


Figure A-25. Cross-Plot of Reservoir Elevation vs. 72-9-21 Piezometer Data

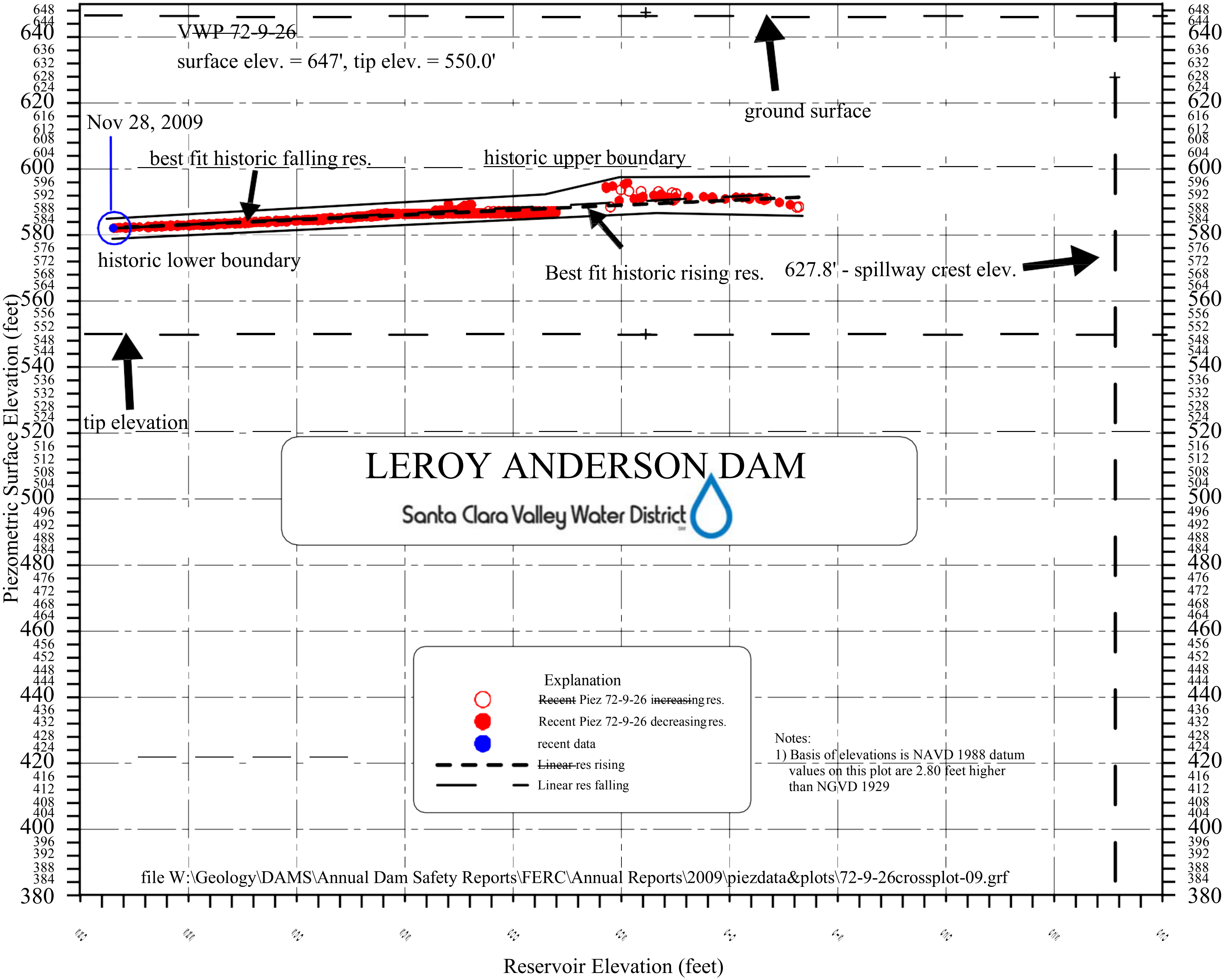
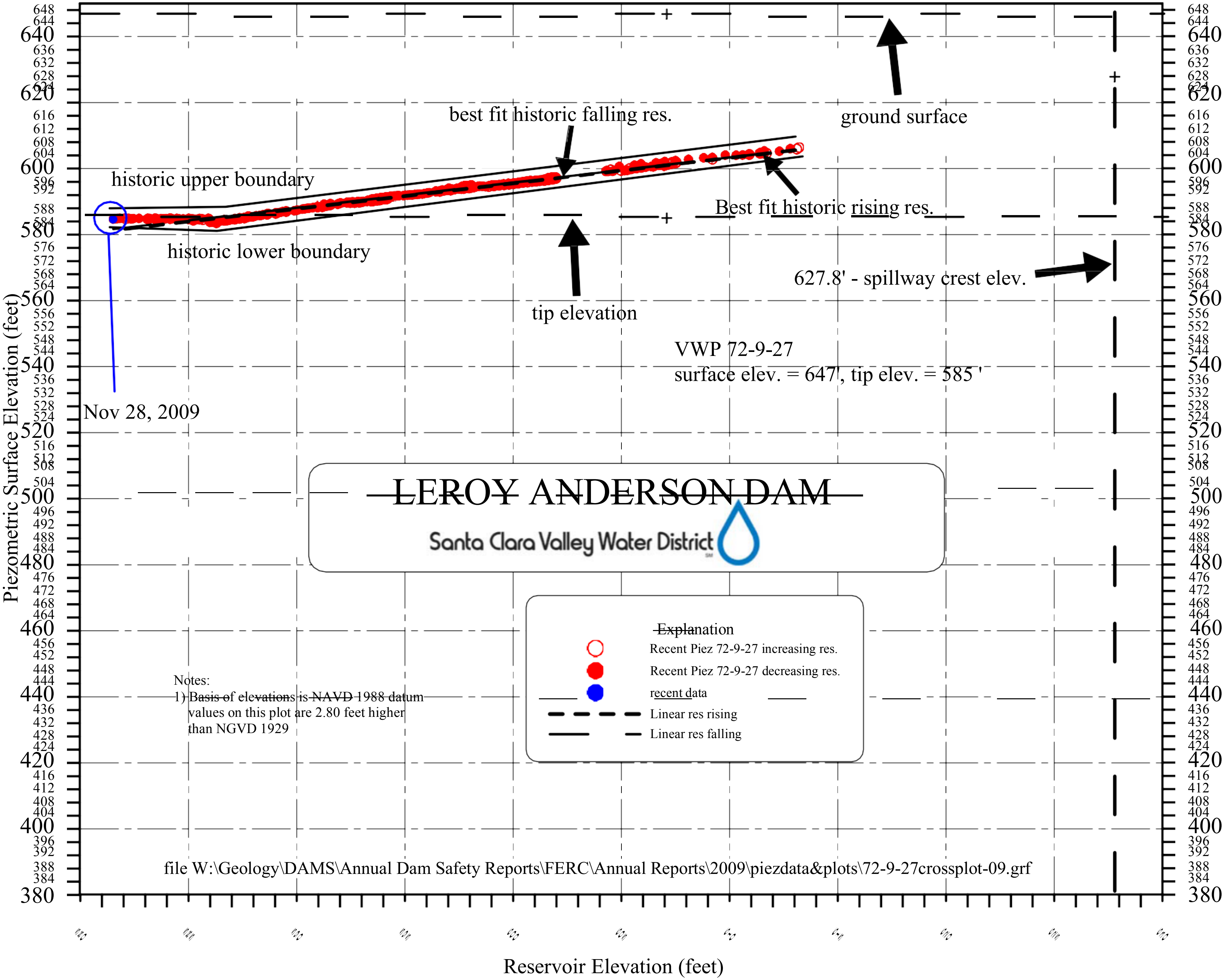


Figure A-26. Cross-Plot of Reservoir Elevation vs. 72-9-21 Piezometer Data



Notes:
1) Basis of elevations is NAVD 1988 datum values on this plot are 2.80 feet higher than NGVD 1929

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Figure A-27. Cross-Plot of Reservoir Elevation vs. 72-9-27 Piezometer Data

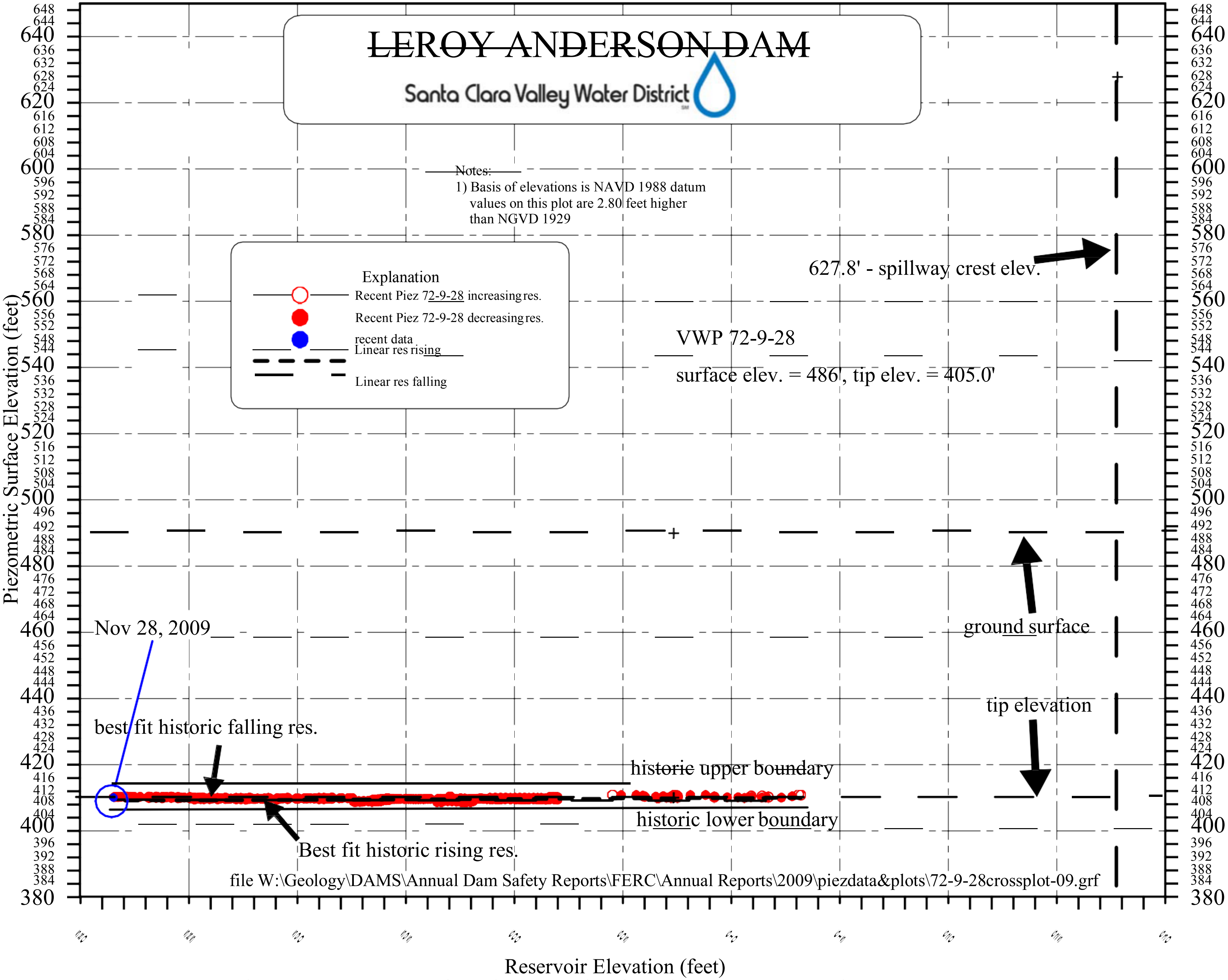


Figure A-28. Cross-Plot of Reservoir Elevation vs. 72-9-28 Piezometer Data

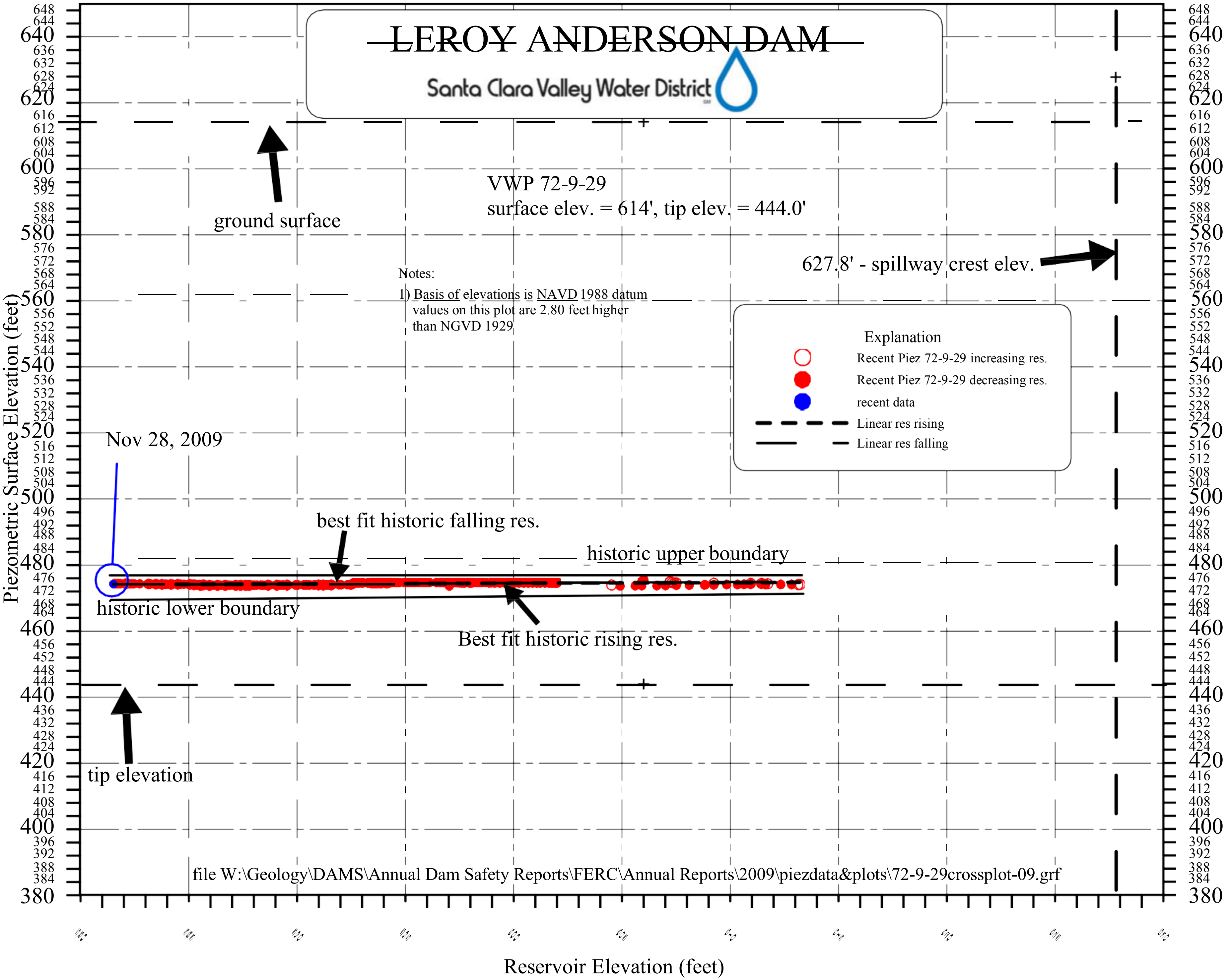


Figure A-29. Cross-Plot of Reservoir Elevation vs. 72-9-28 Piezometer Data

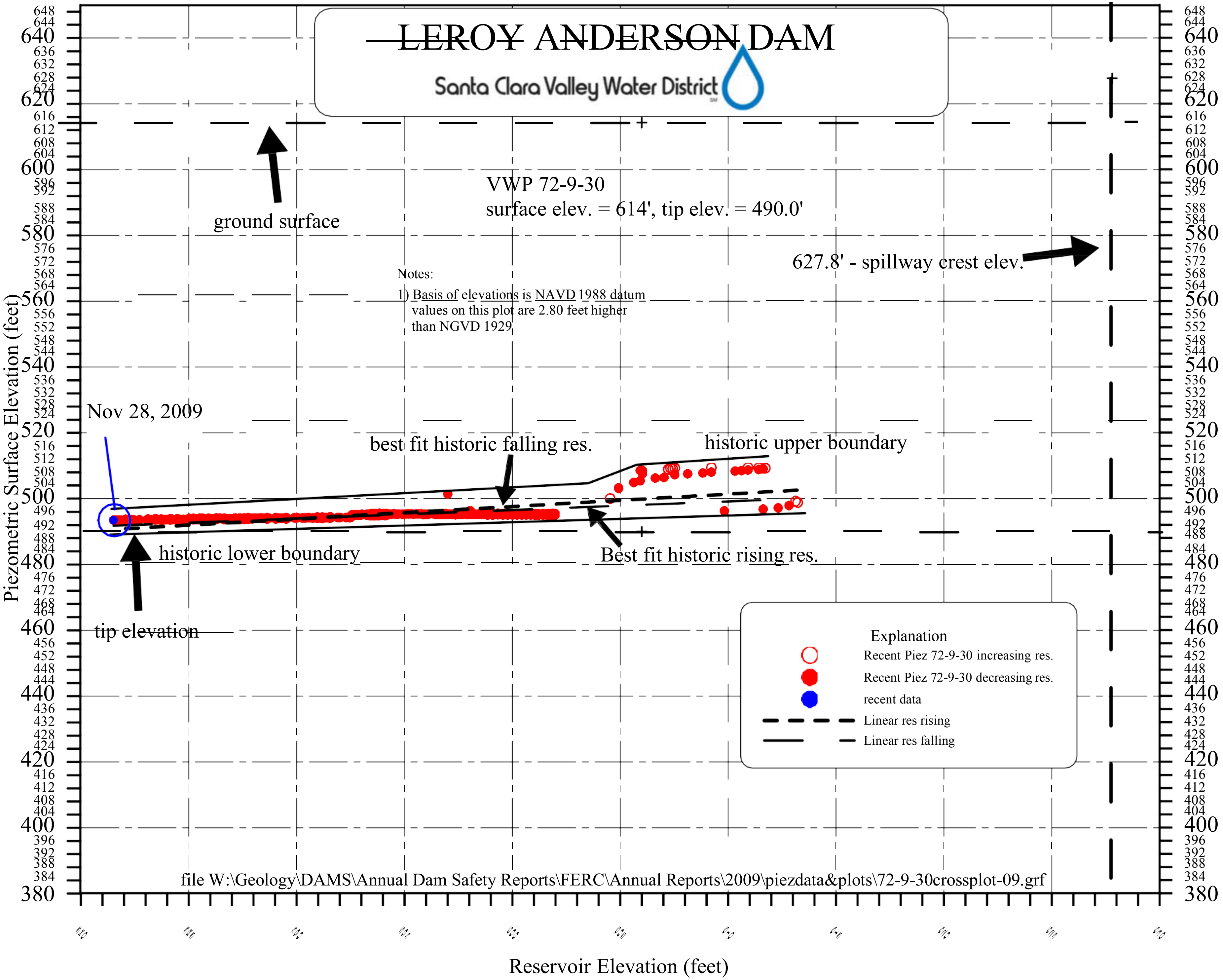


Figure A-30. Cross-Plot of Reservoir Elevation vs. 72-9-31 Piezometer Data

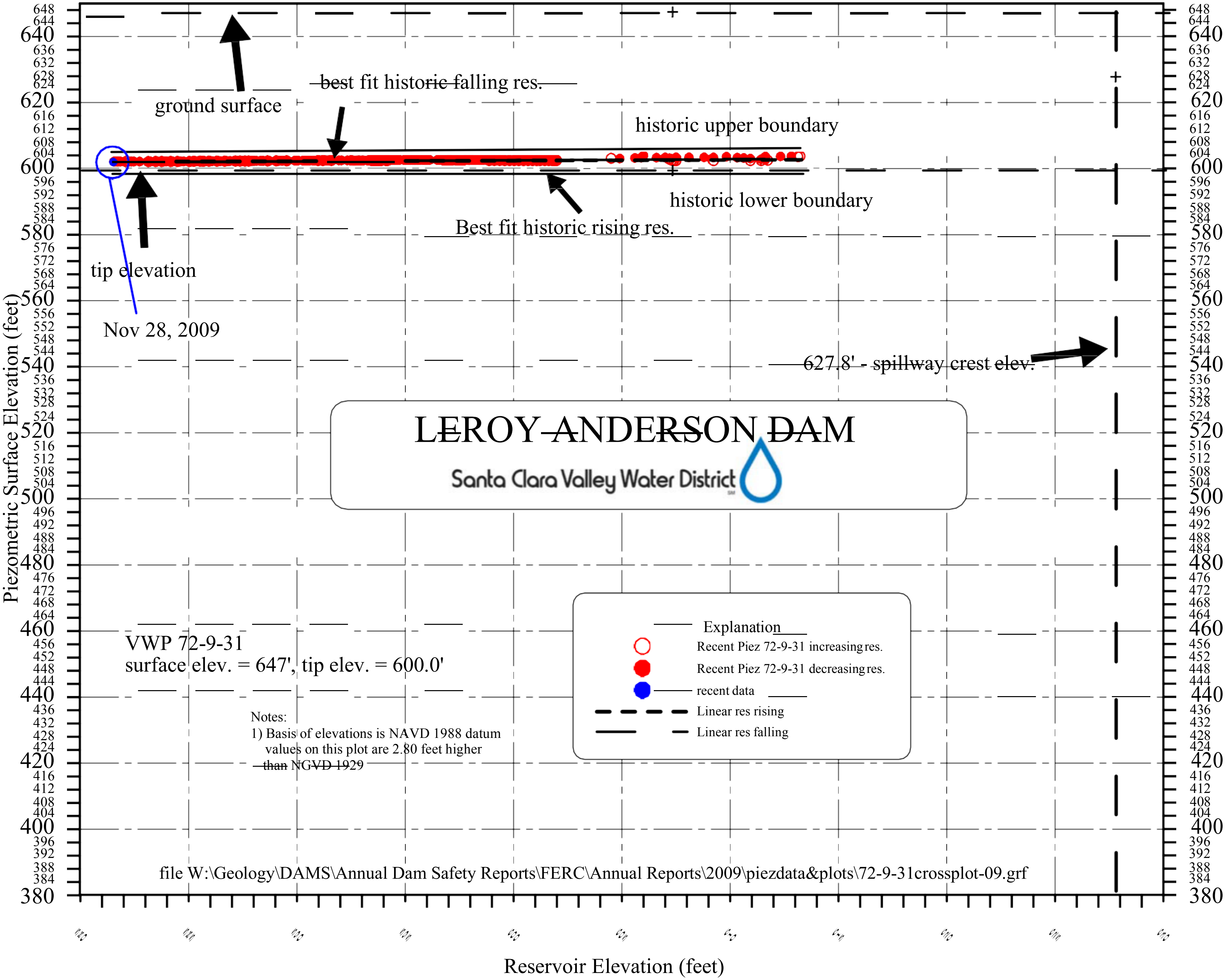


Figure A-31. Cross-Plot of Reservoir Elevation vs. 72-9-31 Piezometer Data

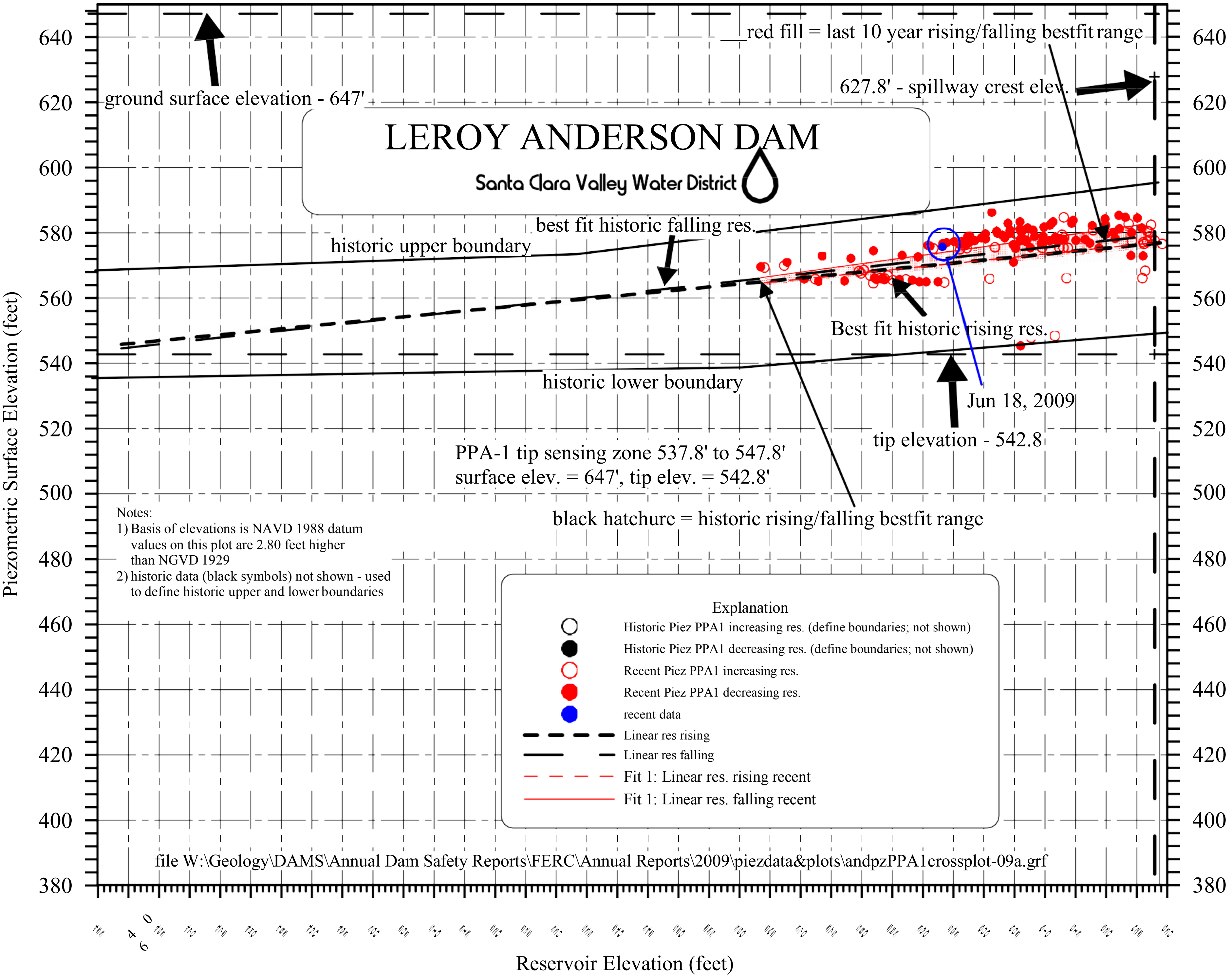
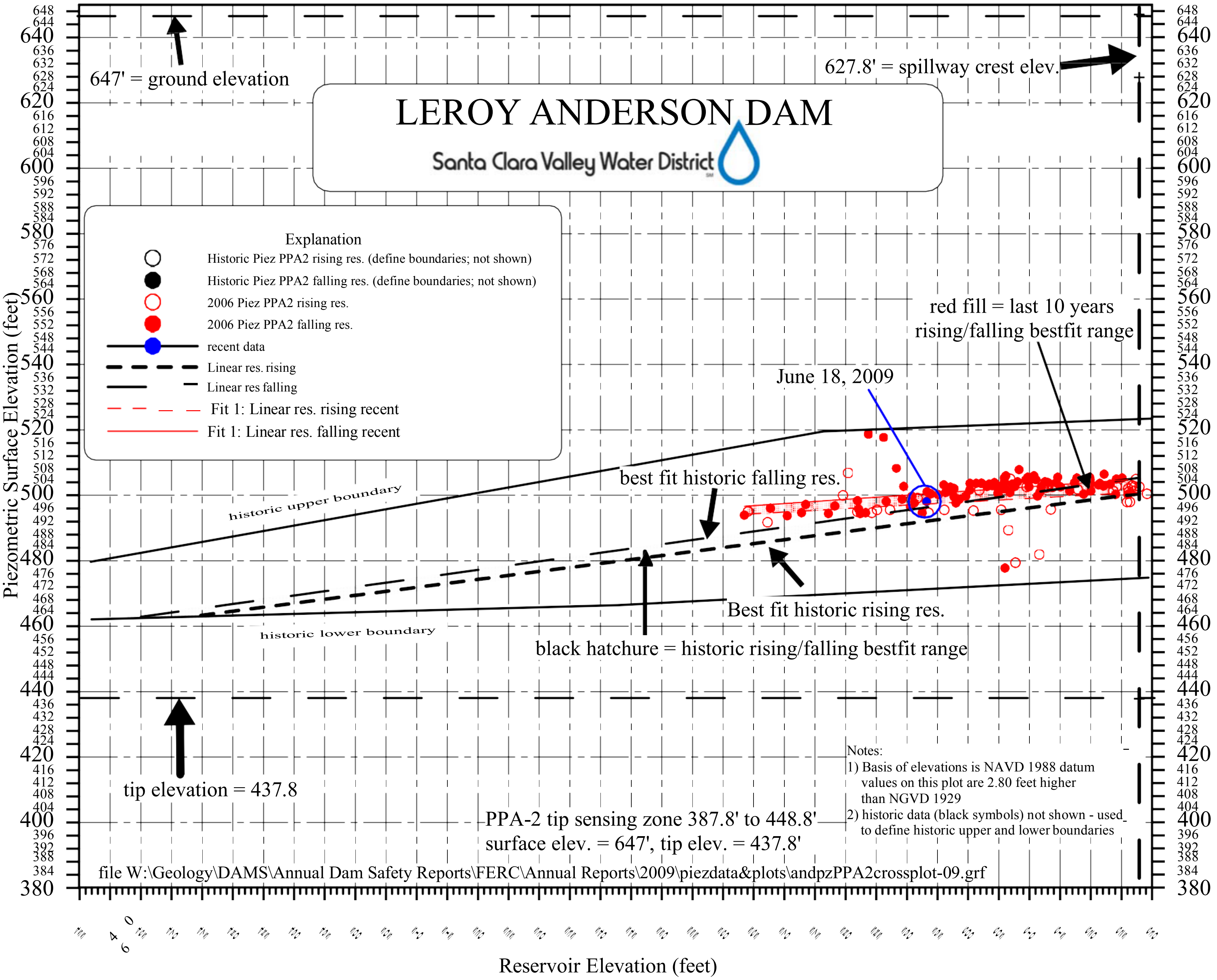


Figure A-32. Cross-Plot of Reservoir Elevation vs. PPA1 Piezometer Data



Notes:
1) Basis of elevations is NAVD 1988 datum values on this plot are 2.80 feet higher than NGVD 1929
2) historic data (black symbols) not shown - used to define historic upper and lower boundaries

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Figure A-33. Cross-Plot of Reservoir Elevation vs. PPA2 Piezometer Data

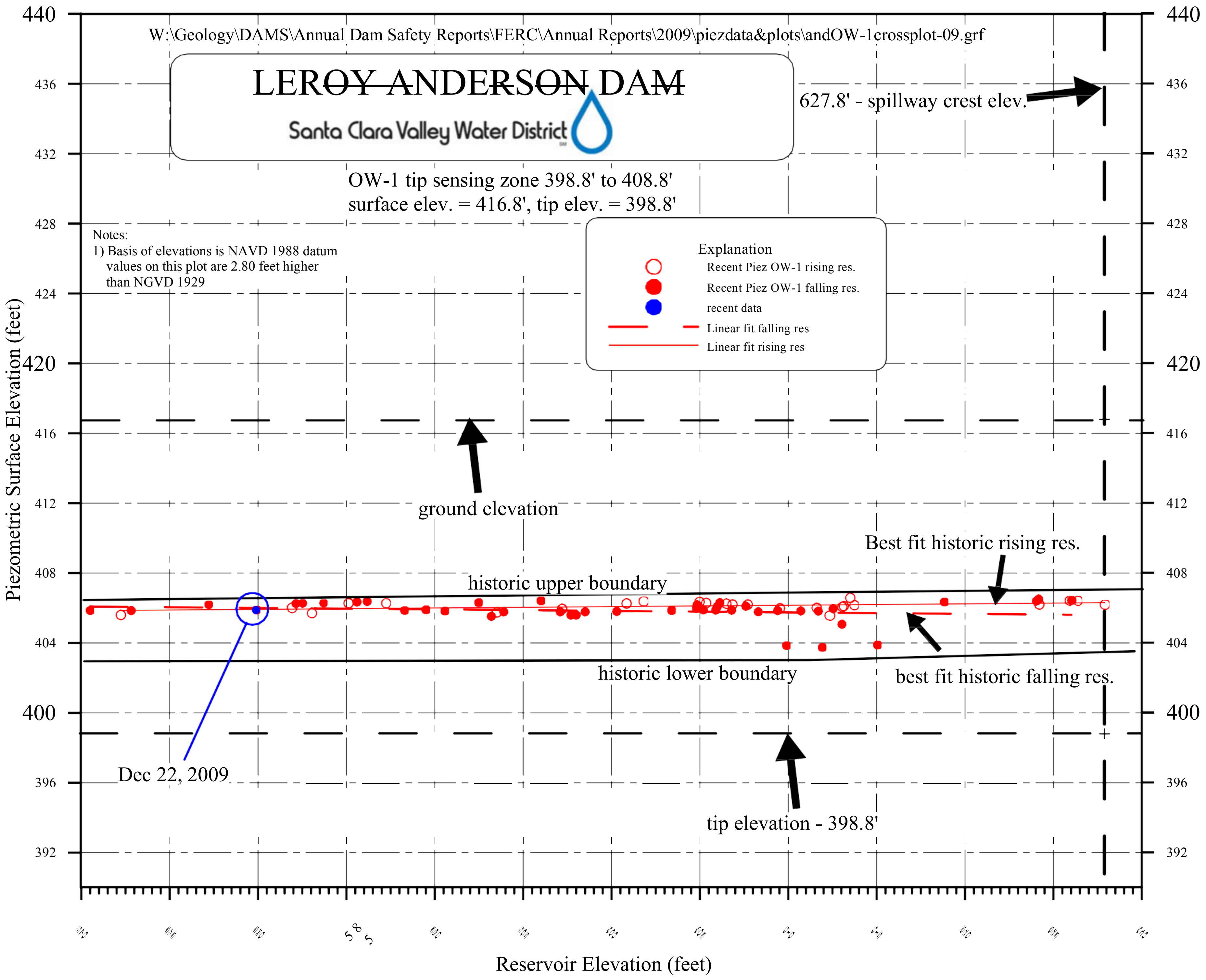

Figure A-34. Cross-Plot of Reservoir Elevation vs. OW-1 Piezometer Data

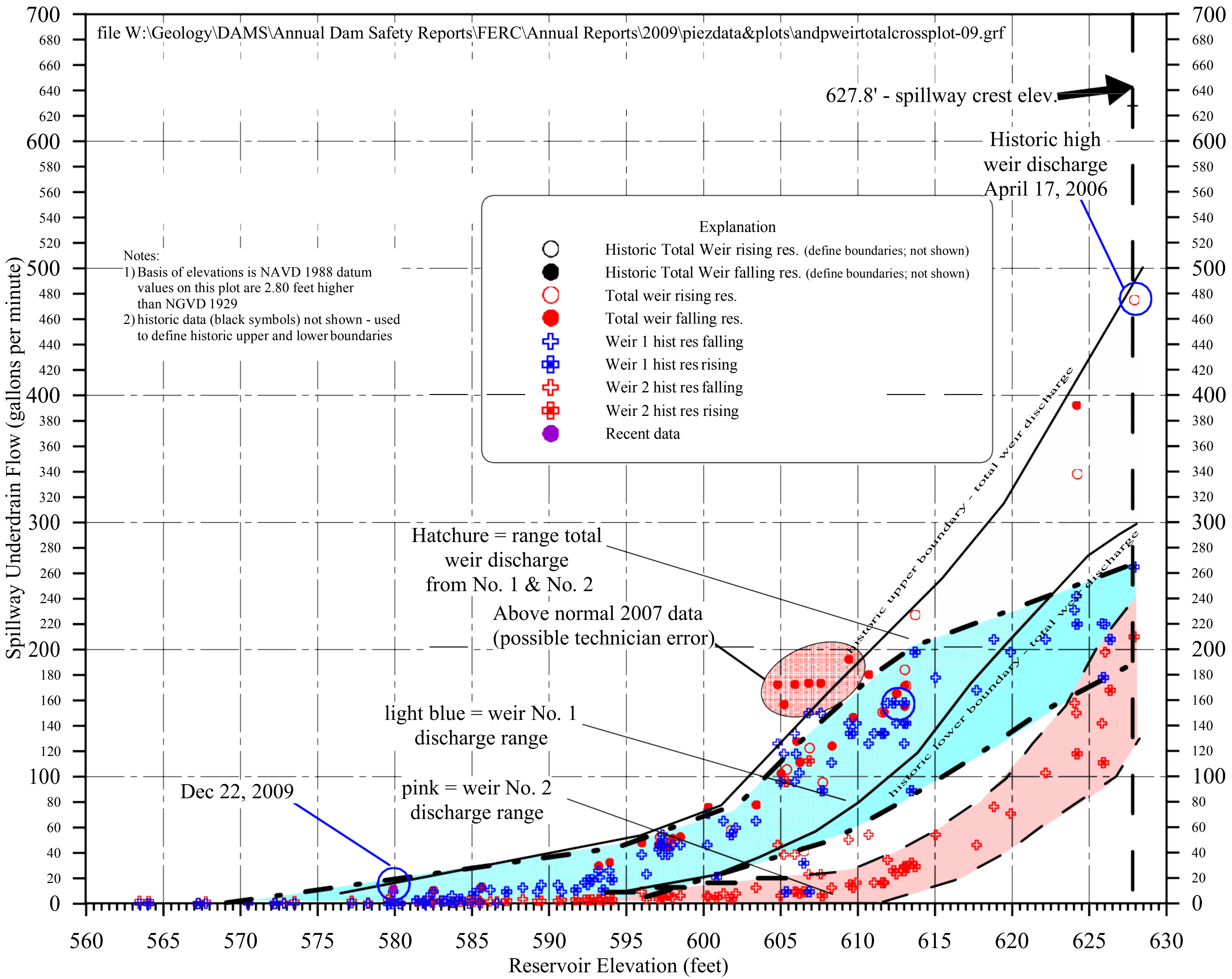

Figure A-35. Cross-Plot of Reservoir Elevation vs. Spillway Weir Discharge, gpm